



AFTAC Project No. VELA T/7704
ARPA Order No. 624
ARPA Program Code No. 7F10

AD 670215

OPERATIONS REPORT
ALEUTIAN ISLANDS EXPERIMENT
OCEAN-BOTTOM SEISMOGRAPHIC EXPERIMENTS

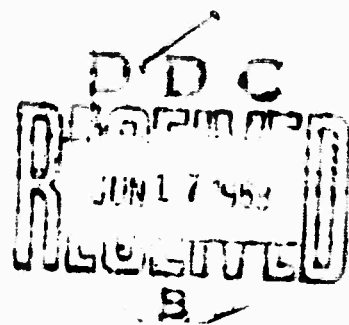
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TEXAS INSTRUMENTS INCORPORATED
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P. O. Box 4621
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Effective Date of Contract: 5 April 1967
Contract Expiration Date: 31 July 1968
Amount of Contract: \$1,054,991



ACKNOWLEDGMENT

This research was supported by the
ADVANCED RESEARCH PROJECTS AGENCY
Nuclear Test Detection Office,
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and accomplished under the technical direction of the
AIR FORCE TECHNICAL APPLICATIONS CENTER
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31 January 1968



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We wish to thank the Naval Station, Adak, Alaska; Naval Communications Station; and Alaskan Communications Region for their assistance in the program. We would also like to thank the Air Weather Service for their monitoring and timely reporting of surfaced units.



ABSTRACT

An Ocean-Bottom Seismograph Aleutian Islands Experiment was conducted during the summer of 1967. The objective of the experiment was to obtain data for the determination of thickness and seismic velocities of the crust and upper-mantle structure by deployment of three linear arrays of instruments in the vicinity of Amchitka Island and by detonation of a series of chemical explosions.

Several tasks involved in the completion of the experiment were equipment preparation, ship-rigging, shakedown cruises, and field operations. In general, the OBS units and auxiliary equipment performed reliably so that the experiment was completed with a minimum number of problems within the specified schedule.



LIST OF ACRONYMS

ABS-USCG	American Bureau of Shipping – United States Coast Guard
AFTAC	Air Force Technical Applications Center
E	Explosion
MARS	Military Affiliated Radio Station
NAVCOMSTA	Naval Communication Station
NEL	Navy Electronics Laboratory
OBS	Ocean-Bottom Seismograph
OEC	Oceanographic Engineering Corporation
P	Pressure
RDF	Radio Direction Finder
S	Station (unit location)
V	Vertical



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SECTION I

INTRODUCTION AND SUMMARY

An Ocean-Bottom Seismograph Aleutian Islands Experiment was conducted during the summer of 1967. The objective of the experiment was to obtain data for the determination of thickness and seismic velocities of the crust and upper mantle structures by deployment of three linear arrays of instruments in the vicinity of Amchitka Island (Figure 1-1) and by detonation of a series of chemical explosions.

Several tasks were involved in the completion of the experiment:

- Equipment preparation
- Ship-rigging
- Shakedown cruises
- Field operations

This report presents a detailed description of all phases of the operations, as well as preliminary evaluations of operations and instrumentation. Detail was stressed so that guidelines for future similar operations could be established using this report.

Equipment preparation (Section II) included the completion of major repairs, necessary modifications and general cleaning of 14 Ocean-Bottom Seismograph units and associated auxiliary equipment. Equipment preparation was completed between 28 April and 8 June.

Ship-rigging involved the acquisition of a suitable vessel and the installation of an engineering house and miscellaneous shipboard equipment. The M/V VIRGO was selected for use during the field experiment, and ship-rigging was accomplished in Port Arthur, Texas, between 12 and 20 May.

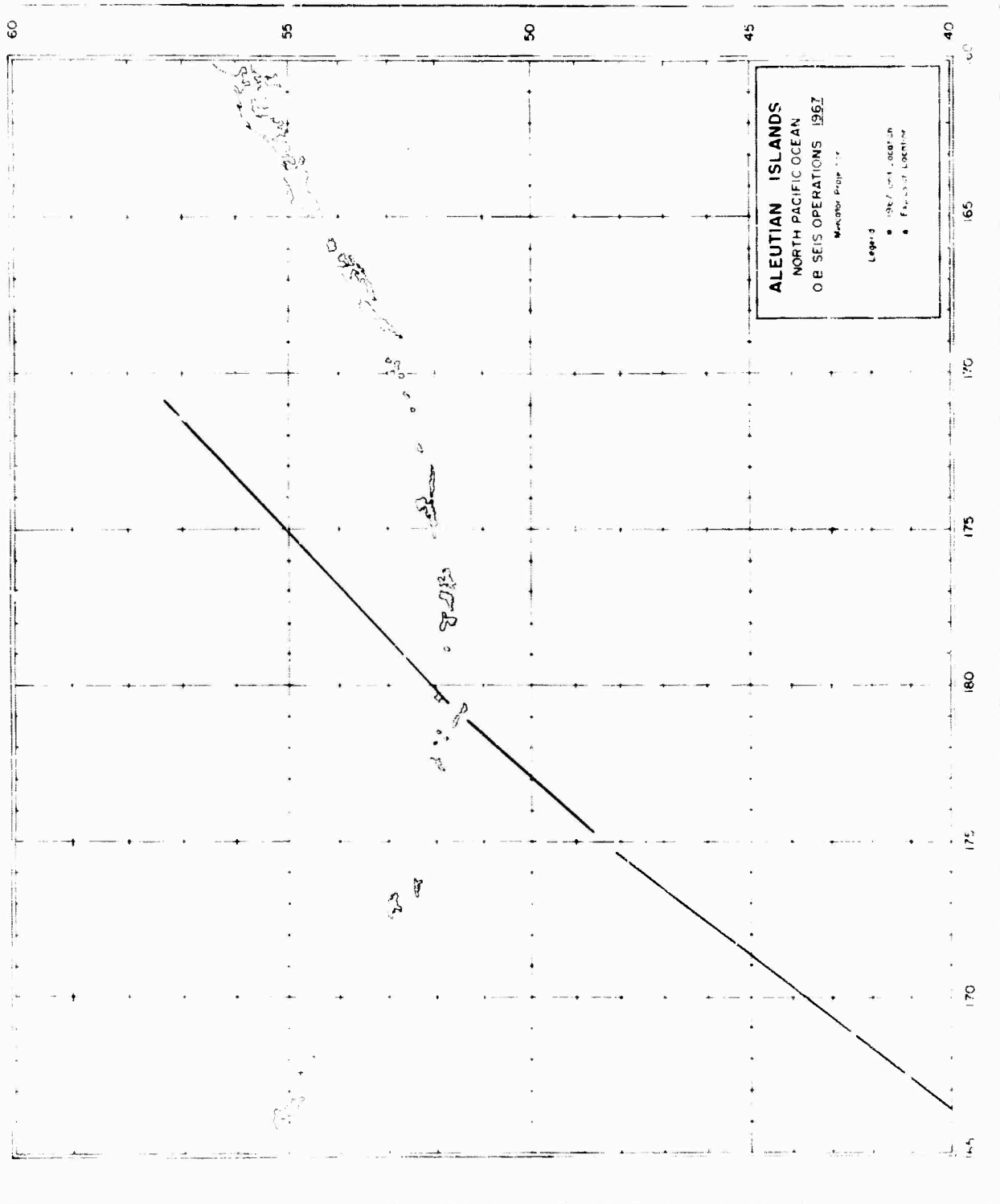


Figure I-1. Aleutian Islands Experiment Linear Arrays



Two shakedown cruises were conducted prior to the commencement of the actual field experiment. The first was conducted in Puget Sound on 17 and 18 June following the loading of the Ocean-Bottom Seismograph units and auxiliary equipment on the M/V VIRGO in Port Angeles, Washington. The second was conducted off Great Sitkin Island on 8 July immediately before the actual field experiment began. During the shakedown cruises, all equipment was checked out; and procedures for the launch, recovery, and shooting operations were verified.

Field operations (Section III) were conducted in three phases between 9 July and 13 September as follows:

- Phase III — 9 through 23 July
- Phase II — 24 July through 31 August
- Phase I — 1 September through 13 September

During field operations, 31 units were deployed and 27 recovered (for a recovery rate of 87 percent), and thirty-five 5-ton chemical explosives were detonated. A total of 314 complete or partial days of usable data was recorded during the experiment, providing information for the completion of the analysis portion of the experiment.

Navigation during the Aleutian Islands Experiment was improved over that of previous experiments with the use of an Omega Navigation system, a Loran A receiver, and radar fixes.

All equipment used during the field operations is evaluated in Section IV, and recommendation for system and operations improvements are presented in Section V. In general, the OBS units and auxiliary equipment performed reliably so that the experiment was completed with a minimum number of problems within the specified schedule. Consequently, recommendations are mainly directed toward improving the accuracy of the data (for example, timing and navigational information) collected during the experiment.

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SECTION II

EXPERIMENT PREPARATION

A. OCEAN-BOTTOM SEISMOGRAPHS AND AUXILIARY EQUIPMENT

Repair and general cleaning of the Ocean-Bottom Seismographs and auxiliary equipment were necessary before beginning the Aleutian Islands Experiment field operations. Under Task V of the Kurile Islands Experiment (Contract F 33657-67-C-0105), minor equipment repairs were made, including

- Replacement of small O-rings
- Replacement of calibration-unit dry cells
- Replacement of back-up clock dry cells
- Minor repair of subsystems
- Minor repair of test equipment
- General cleaning of equipment

Major equipment repairs resulting from weather, operational environment, and unscheduled incidents during the Kurile Islands Experiment were not included in Task V of the previous contract. Major repairs conducted under Task I of the present contract included the following:

- Repair internal subsystems of units which leaked salt water
- Repair of unit 18, which washed up on the rocks during completion of Task I of the Kurile Islands Experiment
- Repair of unit 25, which floated in rough seas for several days
- Repair of auxiliary equipment which suffered saltwater damage due to high winds and storms at sea
- Replacement of all Yardney SILVER-CEL[®] batteries which were one or more years old



Specific repairs and maintenance completed during the Ocean-Bottom Seismograph and auxiliary-equipment preparation are listed in Table II-1.

In addition to the repairs and maintenance performed on the equipment, two modifications of the timing system were completed on the Ocean-Bottom Seismographs. One change was the addition of more digital-clock release times. In the past, the digital-clock configuration offered only four unit-release times — 4, 10, 20, or 40 days after reset time. A field program in which several units are dropped simultaneously or units are dropped, recalled, and redropped on a tightly compressed time schedule requires more freedom of choice in available release times. Therefore, the digital clock was modified to provide clock releases 1, 2, 4, 8, 10, 20, 30, or 40 days after reset time.

The second change allows time pulses from the back-up clock to be recorded. Previously, the only time reference recorded on magnetic tape was digital clock time. Failure of the digital clock renders the data useless (in the case of complete breakdown) or at least increases the difficulty of analysis (in the case of repetitious time). Consequently, the Bulova back-up clock, heretofore used solely for unit release, was modified so that time pulses from the back-up clock could be recorded on the magnetic tape. Pulses are superimposed on the north-south x 1 trace and have sufficiently small amplitude to avoid interference with the seismic data on the trace. The pulses are of different lengths and are placed on the tape at intervals of 10, 20, 30, 40, and 50 sec; 1, 5, and 30 min; and 1 hr.

Two additional items were added to the auxiliary equipment: a secondary timing system and a magnetic tape recorder. Both items were checked and integrated into the existing system. Secondary timing systems were added because analysis of the data recorded during the Kurile Islands Experiment revealed that the W.VV signal recorded at unit reset and after unit recall is often too noisy to supply an easily readable time reference.



Table II-1

REPAIRS AND MAINTENANCE ON OCEAN-BOTTOM SEISMOGRAPH
AND AUXILIARY EQUIPMENT

Ocean-Bottom Seismograph		Auxiliary Equipment	
Unit 1	Repaired sling, bottom plug, and external cables; removed primer from all pressure-ring O-ring surfaces	Sonar transmitter (2 units)	For unit 1: replaced several transistors and rectifiers; repainted cabinet; completed general cleanup. For unit 2: completed general cleanup
Unit 2	Repaired top hemisphere and bottom plug; refaced side-plug surface; removed primer from all pressure-ring O-ring surfaces; replaced diaphragm on pressure transducer	Sonar transducers (3 units)	Replaced special insulated leak-proof cable and complete harness assembly; repaired nosecone and fin assemblies; rebuilt storage rack, checked for broken or damaged crystals
Unit 5	Stripped, reanodized, and repainted entire sphere; repaired side-plug face and bottom plug; repaired transducer (new connector, new diaphragm) and checked crystals and repaired reaction amplifiers	Battery chargers (2 cabinet assemblies)	Replaced three units damaged beyond repair; repaired one unit; replaced both cabinets; completed general cleanup on all units
Unit 10	Removed primer from all pressure-ring O-ring surfaces; realigned tape-recorder heads; reentered vertical seismometer	Playback tape recorder	Completed general cleanup
Unit 13	Repainted top hemisphere and pressure ring; repaired sonar amplifier; realigned tape-recorder heads	Paper chart recorder	Returned to factory for realignment and repair to damaged frame; repaired 5 galvanometers



Table II-1 (Contd)

Ocean-Bottom Seismograph		Auxiliary Equipment	
Unit 15	Stripped pressure ring; removed 0.005 in. material from both sides of ring; re-anodized and refinished pressure ring; repainted top hemisphere and pressure transducer; repaired bottom plug	Galvo amplifiers (2 units)	Added precision potentiometer; completed general cleanup
Unit 16	Repaired bottom plug; overhauled clock; recentered north-south seismometer; replaced bad cell in radio-transmitter battery	Fathometer (2 units)	Returned to factory for check (under warranty); replenished spare-parts kit
Unit 18	Stripped, reanodized, and repainted entire sphere; repaired bottom plug and cover; replaced external cables	D-X navigator (2 units)	Replenished spare parts; completed general cleanup
Unit 19	Checked pressure transducer for broken crystals; recalibrated digital clock crystal; recentered north-south seismometer	Omega navigation system	Repaired recorder and one receiver; replenished spare-parts kit; returned rubidium standard to factory for repair (under warranty); completed general cleanup
Unit 21	Recalibrated digital clock crystal; repaired sonar amplifier	WWV receiver (2 units)	Replaced batteries; completed general cleanup
Unit 22	Repaired sonar amplifier; recentered north-south seismometer	Radio direction-finder	Repackaged and completed design modifications
Unit 24	Stripped, reanodized, and repainted pressure ring; recalibrated digital clock crystal; repaired one reaction-amplifier board	Electrical blasters	Completed general cleanup
Unit 25	Replaced gimbal joint including boot	Oscilloscope (4 units)	Repaired 2 units; completed calibration check and general cleanup
		Function generators	Completed calibration check and general cleanup



Table II-1 (Contd)

Ocean-Bottom Seismograph		Auxiliary Equipment	
General (includes all units)	Completely cleaned and thoroughly checked each internal subsystem; replaced all questionable O-rings and all beacon-light batteries plus spares; replaced antenna springs, cables on bales and other hardware exposed to salt water, and all Yard- ney batteries over 1 year old	High-frequency generators Strobotac RF dummy load and wattmeter Volt ohmmeter (5 units) Hand tools (2 sets)	Completed calibration check and general cleanup Completed general cleanup Completed general cleanup Repaired two units damaged by salt water; completed calibra- tion check and general cleanup Replaced missing and unusable tools; completed general cleanup

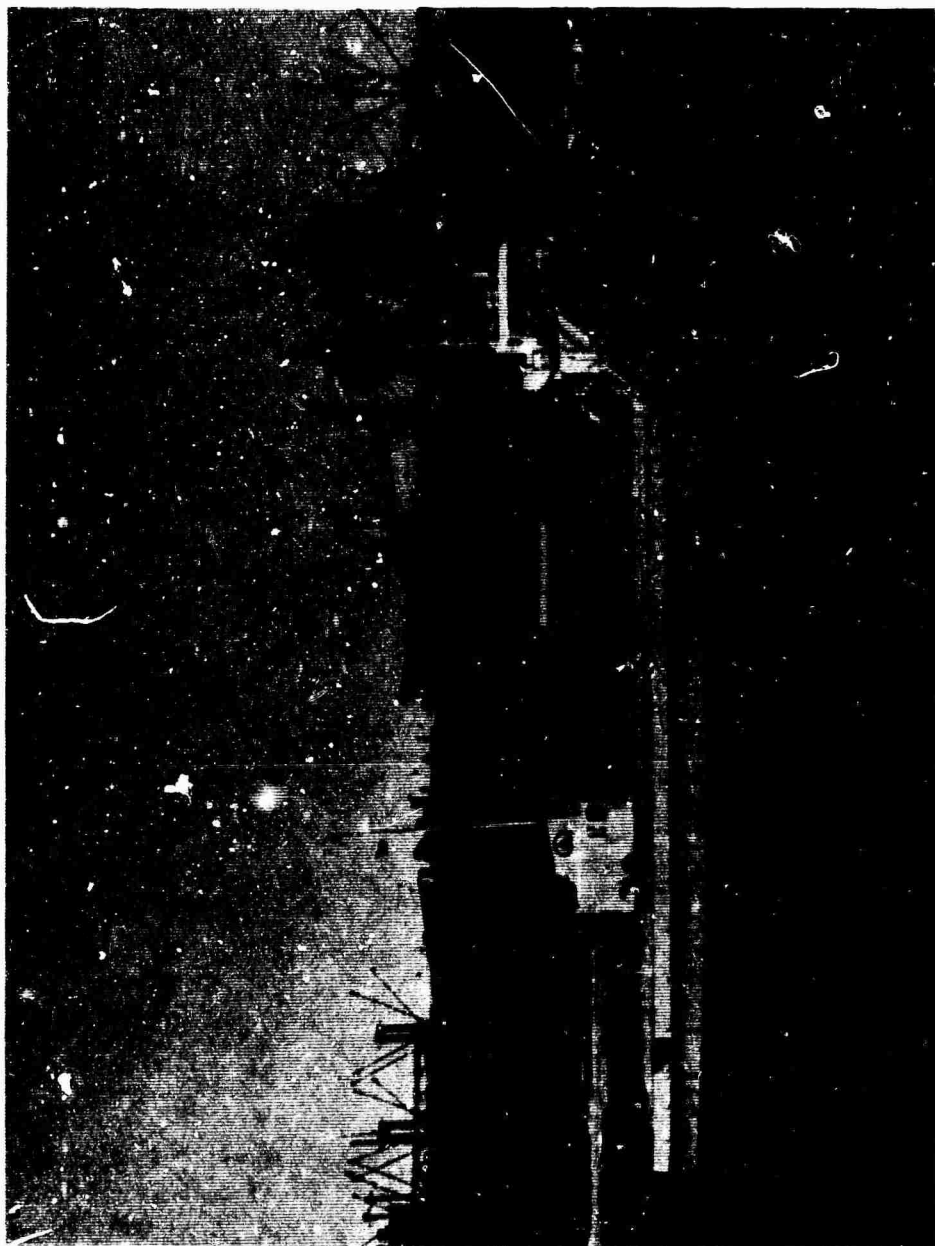


Figure II-1. The M/V VIRGO



Consequently, two Geotech Model 5400-A timing systems were supplied by AFTAC and set up as a secondary timing system. This system supplies a readable time reference which can be recorded on unit magnetic tape and can be easily checked against WWV.

Past field experiments revealed the need for increased recording capability of hydroacoustic data during operations. Therefore, an Ampex Model 300 tape recorder was supplied by AFTAC and used to record the calibration explosion hydroacoustic data.

B. M/V VIRGO

An extensive search by TI personnel was conducted to find a suitable vessel for the Aleutian Islands Experiment field operations. Factors considered in the selection of the ship included availability, configuration, ability to maintain a stable working platform, cost, and owner's experience in marine operations.

The M/V VIRGO (Figure II-1) was found to be the most suitable vessel for field operations and, along with a crew, was chartered from Astro-Marine, Incorporated in Houston, Texas. The ship was designed for deep-sea oceanographic research, and the large deck space (Figure II-2) was adequate for program needs. Specifications for the M/V VIRGO are as follows

Construction	Welded steel hull, twin screw, double bottom and double chines; diesel propulsion equipped with reverse and reduction gears
Control	Full pilot-house control
Length	165 ft
Breadth	36 ft
Depth	15 ft
Draft (full load)	11 ft



Figure II-2. View of Deck of M/V VIRGO



Speed	12 knots (cruising speed); 14 knots (full-speed)
Engines	2 GM Model 16-567C, 1600 hp each
Generators	Two 100-kw, 120/280 v, 3-phase; driven by GM-871 diesels
Steering	Sperry gyrocompass with autopilot
Deck space	4000 sq ft
Certification	ABS - USCG
Electronics	400-fm recorder; radiotelephone; radio direction-finder; Decca RM-329 radar
Quarters	9 ship crew; 19 scientific crew
Life-saving equipment	Two 18-man inflatable rafts; life preservers; life vests; flares
Fuel capacity	57,000 gal
Endurance	8000 mi or 30 days

C. SHIP-RIGGING

The M/V VIRGO was outfitted for field operations in Port Arthur, Texas, between 12 and 20 May. Ship-rigging included installation of the engineering house, crane, firing-line reel, Nova winch, fathometer transducer, and A-frame.

The 45 x 25 ft engineering house stored at the Navai Inactive Ship Maintenance Facility in Orange, Texas, since the completion of the 1966 Kurile Islands Experiment was placed on the deck of the M/V VIRGO (Figure II-3). Installation involved

- Cutting down center legs so that house would fit on deck, installing doublers under legs, and welding house to deck
- Welding padeyes on bulwark and securing house with turnbuckles



- Trimming off tin around the bottom of building, installing angle iron around bottom of building, and waterproofing bottom of building by filling angle iron with cement
- Waterproofing roof of building, required after its removal to facilitate moving house onto the ship
- Welding platform behind the engineering house
- Sandblasting platform and painting platform and house as needed
- Installing eight double floodlights and four double switches for better lighting in house, installing large circuit-breaker panel, and rewiring electrical circuits for optimum operation



Figure II-3. Engineering House Installed on Deck of M/V VIRGO



A P&H Model H-312T fully hydraulic crane was installed on the aft starboard deck (Figure II-4). Installation involved removal of the crane from its carrier, fabrication of a suitable foundation, welding of the foundation to the deck and the crane to the foundation, and the fabrication and welding of a boom rest. Specifications for the crane are as follows:

Boom length	27 to 62 ft
Lifting capacity	5 to 17 tons, depending on boom extension and operation radius
Swing	360°, 4 rpm
Drum capacity	800 ft of 1/2-in. cable
Cable feed control	Berger slack thrower
Engine	GM 4-53N, 4-cylinder diesel
Cab	All-weather, full-vision cab with safety glass windows

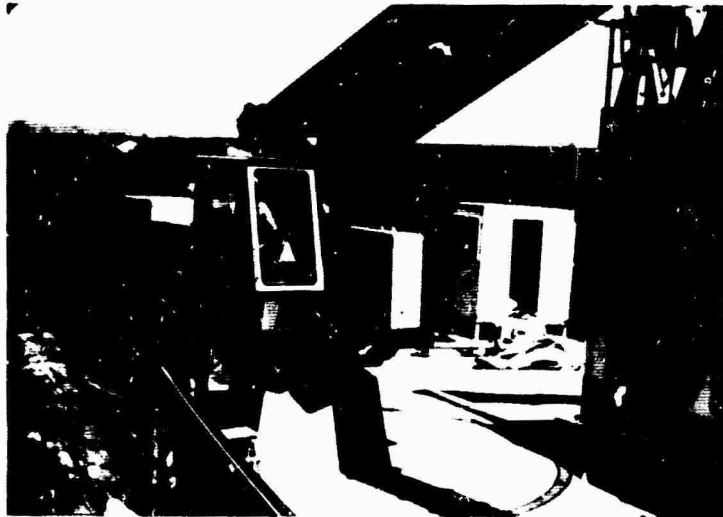


Figure II-4. Hydraulic Crane Installed on Deck of M/V VIRGO



The firing-line reel was mounted on the stack aft of the mast (Figure II-3). Hydraulic equipment on the reel was removed and replaced with an electric motor. A railing around the reel was fabricated and welded to the stack, and a pipe ladder was mounted on the port side of the stack from the deck to the reel. All necessary wiring, circuit breakers, and switches were connected.

The Nova winch was welded to the main deck forward of the stack (Figure II-5). Necessary wiring, circuit breakers, and switches were connected.

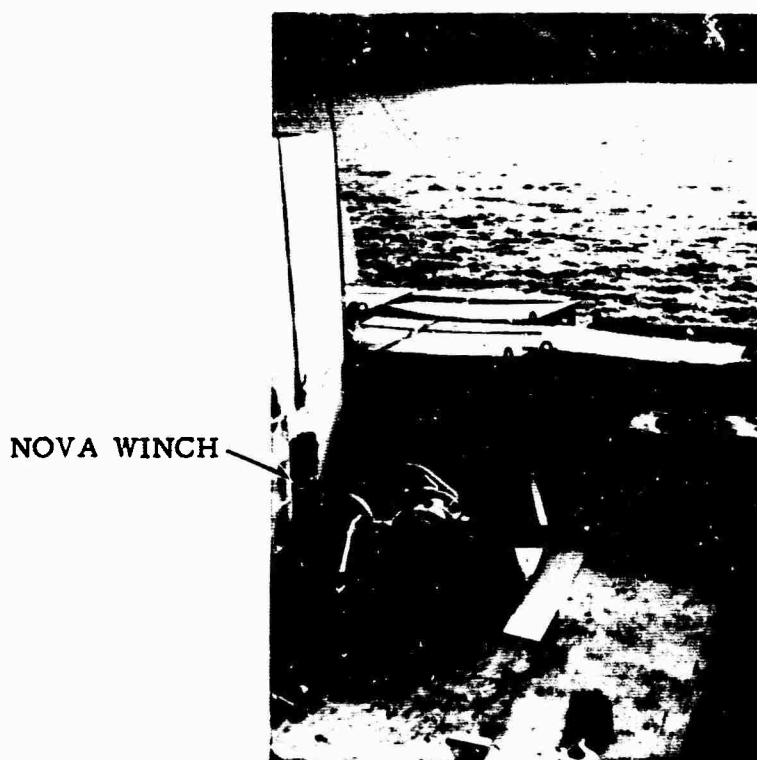


Figure II-5. Nova Winch Installed on Deck of M/V VIRGO



The ship was placed on drydock, and the fathometer transducer was installed in the bottom of the vessel.

The shooting shack was welded to the deck and secured to the port stern (Figure II-6). All necessary wiring, circuit breakers, and switches were connected.

The charge launch A-frame was straightened and welded to the stern (Figure II-7).

Four electrical outlets were installed, one cabinet was relocated, and a plywood work table was placed on one of the bunks in the navigation room. A yardarm with blocks and rope was welded to the aft mast.

Upon completion of ship-rigging, the M/V VIRGO left Galveston, Texas, for Port Angeles, Washington, via the Panama Canal.

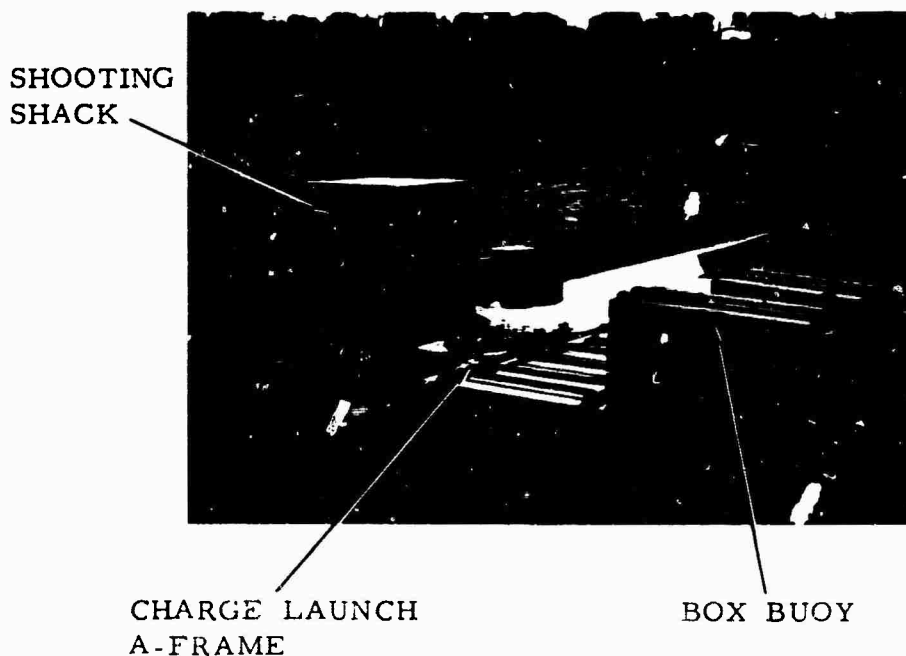


Figure II-6. Shooting Shack Welded to Deck of M/V VIRGO



CHARGE LAUNCH
A-FRAME

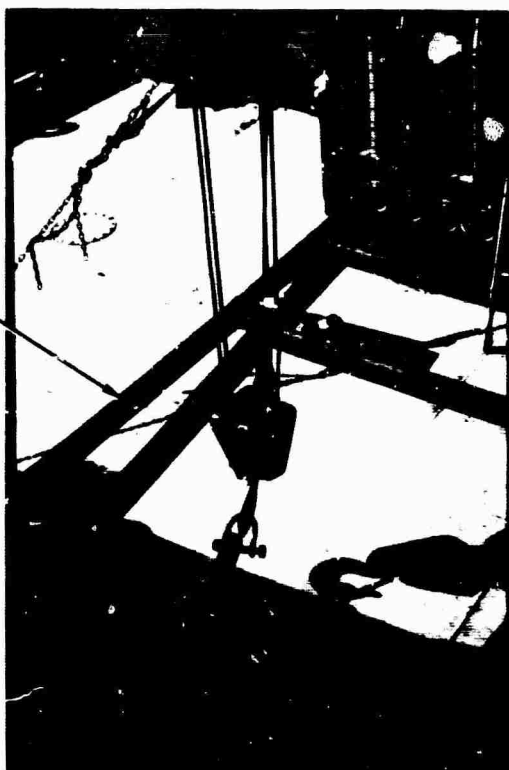


Figure II-7. Charge Launch A-Frame Welded to Stern of M/V VIRGO

D. PORT ANGELES SHAKEDOWN CRUISE

The Ocean-Bottom Seismograph units and associated equipment were shipped to Port Angeles, Washington, on 9 June in two vans designed for transportation of electronic equipment. Equipment installation and final ship-rigging were accomplished by Texas Instruments personnel between 12 and 17 June. Equipment installed is listed in Table II-2.



Table II-2

EQUIPMENT INSTALLED

Engineering house	Ocean-Bottom Seismographs, sonar-recall cabinets and transducers, secondary timing system, Ampex tape recorder, intercom, and miscellaneous equipment and spare parts required to conduct the experiment; extra anchors were secured under the engineering house
Navigation room	Omega navigation system, D-X navigator Loran A/C receiver, Hammarlund receiver, fathometers, OEC handloop, intercom, and miscellaneous charts and maps
Radio room	Collins KWM-2A transceiver, Collins 30L-1 linear amplifiers, R. F. Communications SB6FA transceiver, R. F. Communications RF 302 antenna coupler, Johnson matchbox, Northern N620 auxiliary receiver, direction-finding unit, Cadre 510-A receiver, intercom, and miscellaneous spare parts
Bridge	D-X navigator Loran A/C receiver, Cadre 510-A receiver, and intercom
Playback room	Precision Instruments PI-214 tape recorder, Minneapolis Honeywell 906 Visicorder and 6-channel galvo amplifier, and miscellaneous associated equipment
Shooter shack	SCD-2000 BA-SIE blaster, Minneapolis Honeywell 906 Visicorder and 6-channel galvo amplifier, Specific Products WWVT 5-band receiver, and intercom



Final ship-rigging consisted of the following:

- Mounting necessary antenna on the fore mast and connecting to the direction-finding equipment
- Mounting antenna on the aft mast and connecting to the Omega navigation system
- Mounting 35-ft vertical whip antenna on the bow of the ship and connecting to the Collins radio equipment
- Mounting long-wire antenna between fore and aft masts and connecting them to the Loran A/C receivers and WWV receivers
- Welding additional padeyes to the aft deck of the ship for explosives cage tie-downs
- Connecting the individual intercom units into a workable system
- Secure all equipment for the shakedown cruise

A short shakedown cruise was taken on 17 and 18 June to run preliminary checks on the equipment. Two units were dropped in the Port Angeles Bay on 17 June. The first system (unit 25) contained a Geo Space HS-10 seismometer package, and the second system (unit 21) contained the standard Electrotech EV-17 seismometer package. A line with a rubber buoy was attached to each anchor.

The shakedown mission was undertaken in the mouth of Puget Sound. Overcast skies and fog prevented the floating of a unit to check out the radio direction-finder (RDF) equipment. However, a simulated charge launch was completed to test launch and recording techniques. The capability of the blaster to fire through the 6000 ft of firing line on the large reel was verified. However, it was found that the firing-line reel had to be geared down to prevent an overload on the electrical circuit.



The fathometers and navigational equipment (Omega, Loran, and radar) functioned properly during the shakedown cruise.

Unit 25 was recovered on 18 June by sonar recall with no problems. The tide carried the buoy and unit 21 past the breakwater during the night. The rope had broken, and the buoy was located about 5 mi from the drop site. Sonar recall released the unit which was retrieved 1-1/2 mi from the drop site. The unit did not sustain any damage due to this movement. Retrieval of unit 21 provided an opportunity to test the RDF equipment and the handloop. Some difficulty was experienced with the RDF equipment, but the handloop functioned properly.

On 19 June, the ship was placed on drydock in Seattle, Washington, for repair of damage to the rudder and steering mechanisms caused by adverse weather conditions encountered on the voyage from Galveston, Texas, to Port Angeles, Washington. While in drydock, the Omega navigation system, Ampex tape recorder, sonar-recall cabinets, and secondary timing system were secured using metal bands. Refueling and departure from the shipyard were completed on 21 June.

One hundred tons (twenty 5-ton charges) of Nitramon were loaded and secured on 22 and 23 June at the E. I. DuPont de Nemours and Company plant in Tacoma, Washington (Figure II-8). Extreme tides (25 ft) at the plant dock complicated the explosives' loading. Excessive strain on the O-ring hydraulic seals on the crane caused hydraulic leaks which persisted throughout the project.

The M/V VIRGO departed for Adak, Alaska, on 23 June after all equipment and explosives were secured for the voyage.

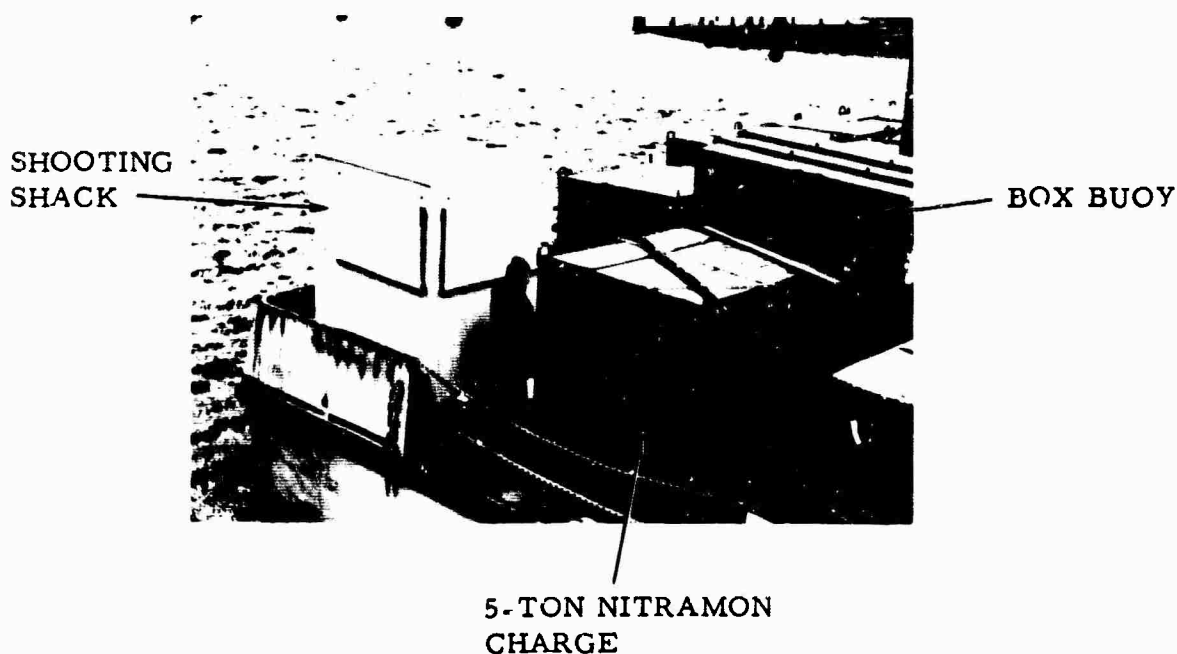


Figure II-8. 5-Ton Nitramon Charge

E. ADAK SHAKEDOWN CRUISE

The M/V VIRGO arrived in Adak, Alaska, on 1 July. TI personnel arrived in Adak between 1 July and 3 July. The following tasks were accomplished during the period 1 to 7 July:

- Established liaison with the Adak Naval Base facilities
- Installed land station (Texas Instruments portable seismograph) at the seismic vault operated by the U.S. Coast and Geodetic Survey
- Conducted thorough review of project objectives, experiment procedures, and safety drills with ship's crew and TI personnel
- Set up communications equipment and hyperbolic Omega equipment in the quarters occupied by the port captain and port assistant in Adak



The final shakedown cruise was taken on 8 July. Unit 24 was floated off Great Sitkin Island, and checks on the RDF equipment and hand-loop were made. The RDF equipment did not function properly, but the hand-loop did. Navigational positions using Omega, Loran A, fathometer, and radar agreed within ± 1 mi. One hydrophone was lost during the detonation of a 4-lb test shot.

Analysis of the shakedown cruise showed that overall ability of personnel to handle operations was greatly improved.

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SECTION III

FIELD OPERATIONS

The objective of the Aleutian Islands Experiment field operations was to obtain data for the determination of thicknesses and seismic velocities of the crust and upper-mantle structures of the Aleutian Arc by deployment of three linear arrays of Ocean-Bottom Seismographs and detonation of a series of 5-ton chemical explosions. All three linear arrays were referenced to a point on Amchitka Island ($51^{\circ}31'00''\text{N}$, $179^{\circ}57'00''\text{E}$) and placed on a line running $\text{N}42^{\circ}\text{E}$ and $\text{S}42^{\circ}\text{W}$ from the reference point.

Two of the arrays (Phase I and Phase III) were designed to obtain information on the crustal structure in the region of Amchitka Island. The third array (Phase II) was designed to obtain information on the upper-mantle structure between 1800 km south and 800 km north of the island. Phase II was planned in conjunction with the CHASE VI experiment, a 2.5-kt chemical explosion scheduled for detonation at $51^{\circ}12'00''\text{N}$, $178^{\circ}26'00''\text{E}$.

Field operations, consisting of a total of 31 instrument drops and thirty-five 5-ton explosions, were completed between 9 July 1967 and 13 September 1967. Individual phase periods are as follows:

- Phase III, 9 July to 23 July
- Phase II, 24 July to 31 August
- Phase I, 1 September to 13 September

Appendix A is a typical list of preparation, launch, and recovery data prepared for unit 21.



A. PHASE III

1. Stations

The Phase III station array consisted of 10 units spaced 20 km apart from 20 km to 200 km N42°E of Amchitka Island (Figure III-1). Unit placement was accomplished between 10 and 12 July. Station S25 was placed west of Semisopochnoi Island off the array line. Unit 16 was initially dropped at location S26 but resurfaced almost immediately. Investigation revealed that failure of a ceramic capacitor in the Bu'ova back-up clock circuit produced a short which activated the release mechanism. All other units were deployed without problems. Unit drop information is presented in Table III-1.

Prime recovery operations for Phase III stations were conducted between 20 and 23 July. Eight units were recovered by sonar recall during the period (Table III-2). Two units (unit 10 at S29 and unit 2 at S32) failed to respond to sonar recall. Subsequent searches of the areas on 31 July, 1 August, and 24 August for possible clock recall were conducted with negative results.

Some difficulty was encountered with sonar recall of units at shallow depths (≤ 60 fm). It was often necessary to pass directly over the unit before the unit would release from the anchor. Various output levels and transducer depths were used in the recovery operations. In general, it was found that shallow instruments should be recalled using low power output and a deep transducer.

Transmitters did not operate immediately after unit surfacing at two locations — S23 and S26. In both cases, initial sighting was visual, and the transmitters did not begin operation until the ship was alongside the unit. Preliminary investigation as to the cause of transmission delay indicates wet Mecca connectors between the unit and the antenna, completing the saltwater transmitter short.

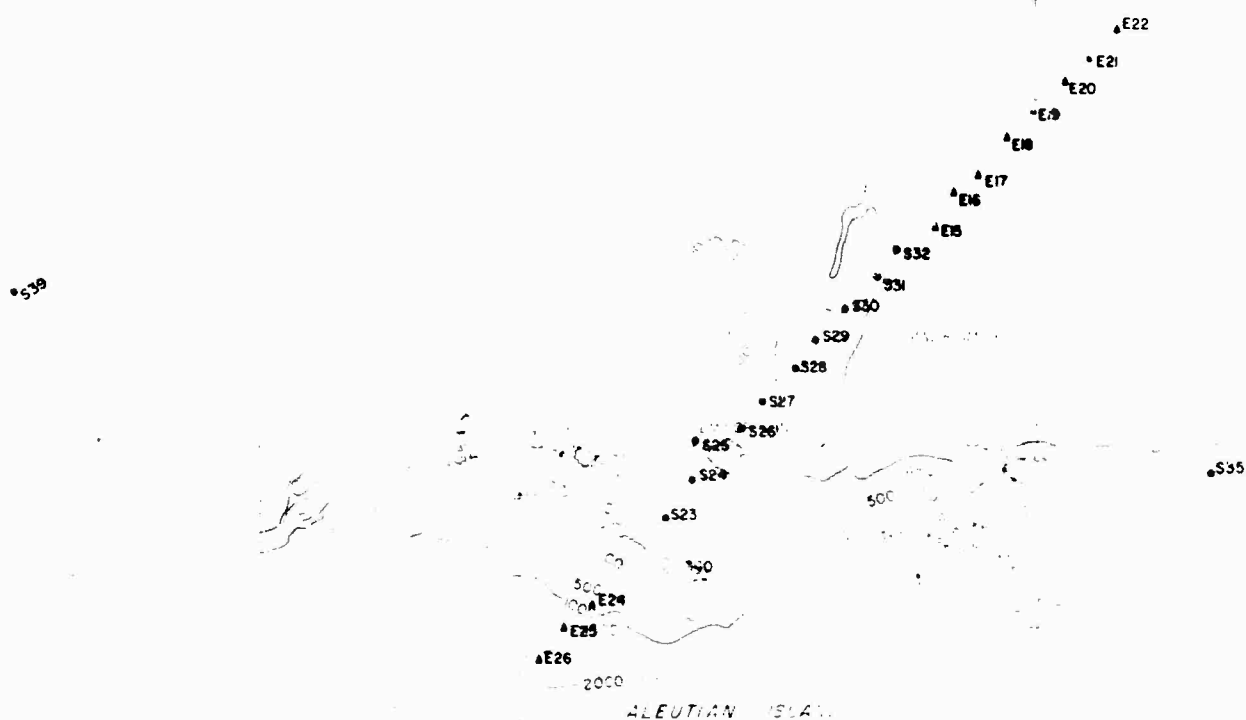


Figure III-1. Phase III Station Array



Table III-1

PHASE III STATION DROP INFORMATION

Station	Unit	Drop Date (GCT)	Location		Est. Accuracy (mi)	Water Depth (fm)
			Latitude	Longitude		
S23	24	10 July	51°41'00"N	179°09'30"E	± 1/2	460
S24	1	10 July	51°51'00"N	179°21'24"E	± 1/2	325
S25	15	10 July	52°02'50"N	179°23'54"E	± 1/2	101
S26	18	11 July	52°05'06"N	179°44'24"E	± 1/2	32
S27	19	11 July	52°13'00"N	179°56'00"E	± 1/2	36
S28	20	11 July	52°21'00"N	179°50'40"W	± 3/4	95
S29	10	12 July	52°29'36"N	179°40'54"W	± 3/4	62
S30	22	12 July	52°38'00"N	179°27'00"W	± 3/4	60
S31	21	12 July	52°46'30"N	179°12'24"W	± 3/4	862
S32	2	12 July	52°53'54"N	179°01'48"W	± 3/4	1749

Operation of the tape recorder in unit 1 at S24 was "jerky", the tape being pulled intermittently during the entire recording period. No usable data were recorded by the unit. The trouble source was traced to a worn bearing.

2. Explosion Program

The Phase III explosion program consisted of eleven 5-ton chemical explosions — eight explosions between 220 km and 360 km N42°E of Amchitka Island (E15 through E22) and three explosions between 40 km and 80 km S42°W of Amchitka Island (E24, E25, and E26). The explosion program was conducted between 16 and 20 July. Phase III explosion locations are presented in Figure III-1, and Table III-3 contains pertinent calibration explosion information. All shot depths were computed from hydroacoustic data. A detailed report on shot-depth determination is presented in the preliminary analysis report under the present contract. * All Phase III explosions were detonated without a misfire. Equipment and explosives involved in each explosion are presented in Table III-4.

* Texas Instruments Incorporated, 1968: Preliminary Analysis Report — Aleutian Islands Experiment, Ocean-Bottom Seismographic Experiments, Contract No. F33657-67-C-1341, 31 Jan.



Table III-2
PHASE III STATION RECOVERY INFORMATION

Sta.	Unit	Recall Method	Component Oper.		Remarks
			Trans-mitter	Beacon Light	
S23	24	Sonar	No	Yes	Transmitter began working when unit was alongside ship
S24	1	Sonar	Yes	Yes	Tape recorder operation jerky; no usable data recorded
S25	15	Sonar	Yes	Yes	Beacon light apparently working throughout recording period
S26	18	Sonar	No	Yes	4-hr attempt at sonar recall on 21 July failed; second attempt on 23 July succeeded. Transmitter began working when unit was alongside ship
S27	19	Sonar	Yes	Yes	—
S28	20	Sonar	Yes	Yes	Seismometer package appeared tilted $\approx 20^\circ$
S29	10	—	—	—	Unit not recovered. Sonar recall attempted on 21 and 22 July; search of area on 31 July, 1 August, and 24 August for possible clock recall also negative
S30	22	Sonar	Yes	Yes	Seismometer package appeared tilted about 45° ; release mechanism bent when unit separated from anchor
S31	21	Sonar	Yes	Yes	—
S32	2	—	—	—	Unit not recovered. Sonar recall attempted on 22 July; search of area on 31 July, 1 August, and 24 August for possible clock recall also negative



Table III-3
PHASE III CALIBRATION EXPLOSION INFORMATION

Event	Event Depth (ft)	Date (1967)	Detonation Time (GCT)	Location		Est. Accuracy (mi)	Water Depth (fm)
				Latitude	Longitude		
E15	747	16 July	20:48:05.4	53°00'12"N	178°46'12"W	± 3/4	1930
E16	755	17 July	02:20:06.1	53°09'12"N	178°37'06"W	± 3/4	2000
E17	671	17 July	22:03:04.8	53°14'48"N	178°24'50"W	± 3/4	2015
E18	678	18 July	01:06:05.4	53°24'42"N	178°12'30"W	± 3/4	2020
E19	679	18 July	03:30:05.5	53°31'20"N	178°00'00"W	± 3/4	2028
E20	665	18 July	06:21:05.4	53°39'06"N	177°46'00"W	± 3/4	2030
E21	664	18 July	23:25:05.5	53°45'54"N	177°32'54"W	± 3/4	2035
E22	672	19 July	02:37:05.2	53°53'50"N	177°20'36"W	± 3/4	2035
E24	670	20 July	00:32:05.6	51°16'40"N	178°35'24"E	± 3/4	760
E25	657	20 July	05:05:05.4	51°10'30"N	178°20'30"E	± 3/4	1925
E26	659	20 July	07:50:05.5	51°01'36"N	178°10'42"E	± 3/4	1785

Explosion-detonation safety procedures were established before commencement of the experiment and were followed throughout the experiment (Appendix B). During the explosion preparation, launch, and detonation, specific steps are followed.

First, the charge is placed on the A-frame with about 1 ft of the cage extending over the stern of the ship. The charge is secured by chains connected to padeyes on the deck, and the harness is tied to the top of the charge. Then, the charge-support rope is tied to the harness and the box buoy; and the line buoys are tied to the charge-support rope. The box buoy is launched using the crane, and the ship pulls ahead slowly until the box buoy and charge-support rope are floating directly behind the ship.

All radar and transmitting equipment are turned off and secured after a radar sweep is made to determine if any ships are in the area. Then, the shooter and safety engineer proceed to the explosives magazine and remove the necessary primers, boosters, and caps.



Table III-4
EQUIPMENT AND EXPLOSIVES

<u>Equipment</u>	<u>Description</u>
Box buoy	Wooden container measuring 8 x 4 x 4 ft, reinforced with steel rods, and containing styrofoam blocks; the box buoy is used to support the charge in the water before detonation
Charge support rope	1-1/2 in. nylon line connected between the box buoy and the charge harness
Line buoys	Three styrofoam blocks (10 x 20 x 36 in.) attached to the charge support line at approximately 150-ft intervals to help slow the charge descent after launch
Charge harness	1-in. nylon line attached to the four corners of the charge cage and the charge support rope
Main charge	5.35 tons of explosive consisting of two hundred thirteen 50-lb and three 10-lb cans of Nitramon WW-EL oxidizing compound prepackaged in metal containers measuring 6 x 6 x 6 ft
Primers	Three EL 637 primers (7 lb)
Boosters	Three 1-lb water-work boosters
Caps	Three SSS electric blasting caps
Firing line	6000 ft of 18 Tc-WPK telephone wire wound on firing-line reel mounted on the rear of the ship's stack
Blaster	Model SCD-2000 BA-SIE electrical blaster
A-frame	Launch platform constructed of 4-in. pipe in the shape of an "A," measuring 6 ft across the top and arm and 8 ft along the two legs; the bottom of the A-frame is attached on swivels to the deck of the ship at the stern; the charge is placed on the A-frame and is launched by raising the top of the A-frame with the crane



The blasting caps are placed in the lead-lined safety box, checked for continuity, and connected to the firing line. The primers, boosters, and caps are placed in the charge cage, making the charge armed and ready for launch.

Next, the chains are removed from the charge, the A-frame is tilted, and the charge is launched. The ship pulls away using one engine, and the firing line is reeled out. When approximately 3500 ft of firing line has been reeled out, the ship is stopped, the radar is turned on, and a sweep is made to insure that no ships are in the area. Then, the charge is detonated.

After detonation, the firing line is reeled in and all equipment secured on the back deck. The box buoy and charge-support rope are retrieved.

Hydroacoustic data are recorded using a hydrophone attached to the box buoy and two hydrophones hung over the side of the ship. Equipment used to record the hydroacoustic data follows:

- Geo Space MP-8 pressure-sensitive hydrophones
- Texas Instruments dual-hydrophone sensor
- Specific Products WWVT 5-band receiver
- Minneapolis Honeywell 906 12-channel Visicorder paper recorder
- Minneapolis Honeywell 6-channel galvo amplifier
- Ampex 300 series FM carrier magnetic tape recorder (modified as per 508234)
- No. 6145-243-8466 assault-wire signal cable



B. PHASE II

1. Stations

The Phase II station array consisted of 11 units, six between 50 km and 500 km N42°E of Amchitka Island and five between 600 km and 1400 km S42°W of Amchitka Island (Figure III-2). The northern stations were deployed between 24 and 26 July. Stations to the south of Amchitka Island were deployed between 4 and 6 August. Unit drop information is presented in Table III-5. No major problems were encountered during Phase II station deployment.

Table III-5
PHASE II STATION DROP INFORMATION

Station	Unit	Drop Date (GCT)	Location		Est. Accuracy (mi)	Water Depth (fm)
			Latitude	Longitude		
S11	16	24 July	51°50'00"N	179°21'30"E	± 1	320
S12	21	25 July	52°12'48"N	179°55'42"E	± 1	36
S13	5	25 July	52°51'06"N	179°03'24"W	± 1	1500
S14	22	26 July	53°32'00"N	178°00'00"W	± 1	2030
S15	20	26 July	54°10'06"N	176°58'00"W	± 1	2025
S16	15	26 July	54°47'48"N	175°50'30"W	± 1	2000
S17	24	4 Aug.	47°24'48"N	173°36'24"E	± 1	2760
S18	18	5 Aug.	45°59'00"N	172°02'48"E	± 1	3020
S19	17	5 Aug.	44°30'30"N	170°26'54"E	± 1	720
S20	13	6 Aug.	43°03'48"N	169°03'54"E	± 1 1/2	2740
S21	25	7 Aug.	41°34'36"N	167°42'12"E	± 1 1/2	2840



● S37

▲ E12

▲ E13

▲ E14

● S16

● S15

● S14

● S13

● S12

● S11

● S40

● S39

● S38

● S35

▲ E29

● S17

● S18

▲ E11

● S19

● S20

▲ E10

● S21

▲ E27

▲ E9

ALEUTIAN ISLANDS
NORTH PACIFIC OCEAN
O.B. SEIS OPERATIONS 1967
Mercator Projection

Legend
● 1967 Unit Location
▲ Explosion Location

Figure III-2. Phase II Station Array



Primary recovery operations for Phase II stations were conducted between 12 and 20 August. Ten units were recovered by sonar recall during the period, and one unit (unit 5 at S13) failed to respond to sonar recall (Table III-6). All of the units deployed on the southern leg of the array (S17 through S21) were recovered between 12 and 17 August.

Transmitters did not operate immediately after unit surfacing at two locations (S18 and S20). Recall of unit 18 at S18 was attempted during the day, but the search was abandoned after 6 hr with no signal from the unit. After the remainder of the units along the southern leg were recovered, the ship returned to S18. Both the handloop and the Hammarlund receiver picked up the signal from unit 18, and the unit subsequently was retrieved 14 mi east of the drop site. Unit 13 at S20 was recalled at night and was retrieved easily with the aid of the beacon light.

Five of the units on the northern leg of Phase II operations responded to sonar recall. Sonar recall of unit 5 at S13 on 18 August proved unsuccessful. A subsequent search of the area on 24 and 25 August for possible clock recall also proved unsuccessful.

The transmitter on unit 20 (S15) operated intermittently after surfacing, although the unit did transmit long enough to determine that the unit had surfaced. The unit was recalled at night, but stormy weather delayed sighting the beacon light.

Beacon lights on units 21 and 15 (S12 and S16) did not operate upon surfacing. Both units were recalled and recovered during daytime, and both transmitters functioned properly. Batteries had been removed from the unit 21 beacon light (S12) before the unit drop because of shallow water (36 fm) and scheduled length of the drop (30 days). The beacon-light pressure switch does not activate above a depth of 100 fm; battery power for the light would have been drained during the first 2 weeks. A battery wire on unit 15 (S16) was pinched between the light case and the top hemisphere of the unit causing an operational failure.



Table III-6

PHASE II STATION RECOVERY INFORMATION

Sta.	Unit	Recall Method	Component Oper.		Remarks
			Trans-mitter	Beacon Light	
S11	16	Sonar	Yes	Yes	—
S12	21	Sonar	Yes	—	Beacon light batteries not placed in unit because of drop depth (36 fm) and length of recording period
S13	5	—	—	—	Unit not recovered. Sonar recall attempted on 18 August; search of area on 24 and 25 August for possible clock recall also negative
S14	22	Sonar	Yes	Yes	—
S15	20	Sonar	No	Yes	Unit recovered at night; transmitter intermittent until unit alongside ship
S16	15	Sonar	Yes	No	Beacon light not working because of pinched battery wire
S17	24	Sonar	Yes	Yes	Recorder take-up reel not functioning properly, but recorder pulled tape which collected in bottom pan
S18	18	Sonar	No	Yes	Unit released by sonar recall on 12 August, but transmitter not operating; transmitter operating upon return to area on 17 August. Unit recovered 14 mi from drop site
S19	19	Sonar	Yes	Yes	—
S20	13	Sonar	No	Yes	Unit recovered at night; transmitter intermittent until unit alongside ship. Tape playback revealed all channels dead; no usable data recorded during drop
S21	25	Sonar	Yes	Yes	—



Shipboard playback of the tape from unit 13 (S20) revealed that the digital clock and 12.5-Hz reference-trace channels were dead. The unit's digital clock was changed and checked. Subsequent playback of the tape from unit 13 revealed that all channels were essentially dead, with only occasional large signals appearing on the P and V channels. No usable data were recorded during the drop. The reason for the malfunction was not determined; no malfunctions were noted on test tapes recorded by unit 13 before the drop at S20 and after recovery.

2. Explosion Program

The Phase II explosion program consisted of eight 5.35-ton chemical explosions — three explosions between 600 km and 800 km N42°E of Amchitka Island (E12 through E14) and five explosions between 500 km and 1500 km S42°W of Amchitka Island (E9 through E11, E27, and E29). Phase II explosion locations are presented in Figure III-2; Table III-7 contains pertinent calibration explosion information. All shot depths were computed from hydroacoustic data. A detailed report on shot-depth determination is presented in the preliminary analysis report under the present contract.

Explosions E12 through E14 were detonated on 27 July after deployment of the stations along the northern leg of the Phase II layout. The explosions were detonated without a misfire.

Table III-7

PHASE II CALIBRATION EXPLOSION INFORMATION

Event	Event Depth (ft)	Date (1967)	Detonation Time (GCT)	Location		Est. Accuracy (mi)	Water Depth (fm)
				Latitude	Longitude		
E9	623	7 Aug.	21:35:03.8	40°04'42"N	166°23'36"E	± 1 1/2	3040
E10	608	9 Aug.	03:55:02.2	42°17'54"N	168°19'06"E	± 1 1/2	2890
E11	603	11 Aug.	00:25:01.8	45°44'00"N	171°40'42"E	± 1	3085
E12	642	27 July	20:30:05.2	56°31'36"N	172°15'54"W	± 1	520
E13	631	27 July	07:31:05.6	56°03'12"N	173°29'48"W	± 1	1775
E14	631	27 July	01:40:05.3	55°24'18"N	174°44'24"W	± 1	1955
E27	629	8 Aug.	04:40:03.7	40°51'36"N	167°02'18"E	± 1 1/2	2970
E29	615	11 Aug.	20:36:02.2	48°05'40"N	174°27'30"E	± 1	2850



The remainder of the Phase II explosions were detonated between 7 and 11 August after deployment of the stations along the southern leg of the Phase II layout. The explosive program was delayed during the CHASE VI countdown and was resumed after sufficient information was received indicating that the CHASE VI detonation would not be accomplished within the time-frame of the OBS Phase II operation. It was anticipated that the data recorded from the CHASE VI experiment would allow a gross determination of the island arc's upper-mantle structure. The failure to receive data from the CHASE VI experiment leaves only information obtained from the OBS calibration explosions which were not expected to penetrate the mantle.

The first attempt to detonate explosion E10 resulted in a misfire. Standard procedures were employed to cut the charge from the box buoy. The ship was backed to within 1/2 mi of the box buoy, and another attempt was made to detonate the charge. Since the charge did not detonate, the firing line was cut and the ship pulled away. Next, the ship was eased up to the box buoy. A 25-ft loop of chain was connected to the crane hook, and the chain loop was thrown over the box buoy and allowed to fall past the buoy into the water. Using the crane, the chain loop was pulled up, exposing the top of the charge-support rope. The charge-support rope then was cut using a sharp knife attached with metal clamps to a boat hook. This procedure allows the charge to sink to the bottom, where pressure and salt water cause rapid deterioration of the individual cans of Nitramon. In no way do the released charges pose a hazard to navigation.

C. PHASE I

1. Stations

The Phase I station array consisted of 10 units spaced 20 km apart from 20 km to 200 km S42°W of Amchitka Island (Figure III-3). Units were deployed between 31 August and 3 September. Unit drop information is presented in Table II-8. No major problems were encountered during Phase I station deployment.

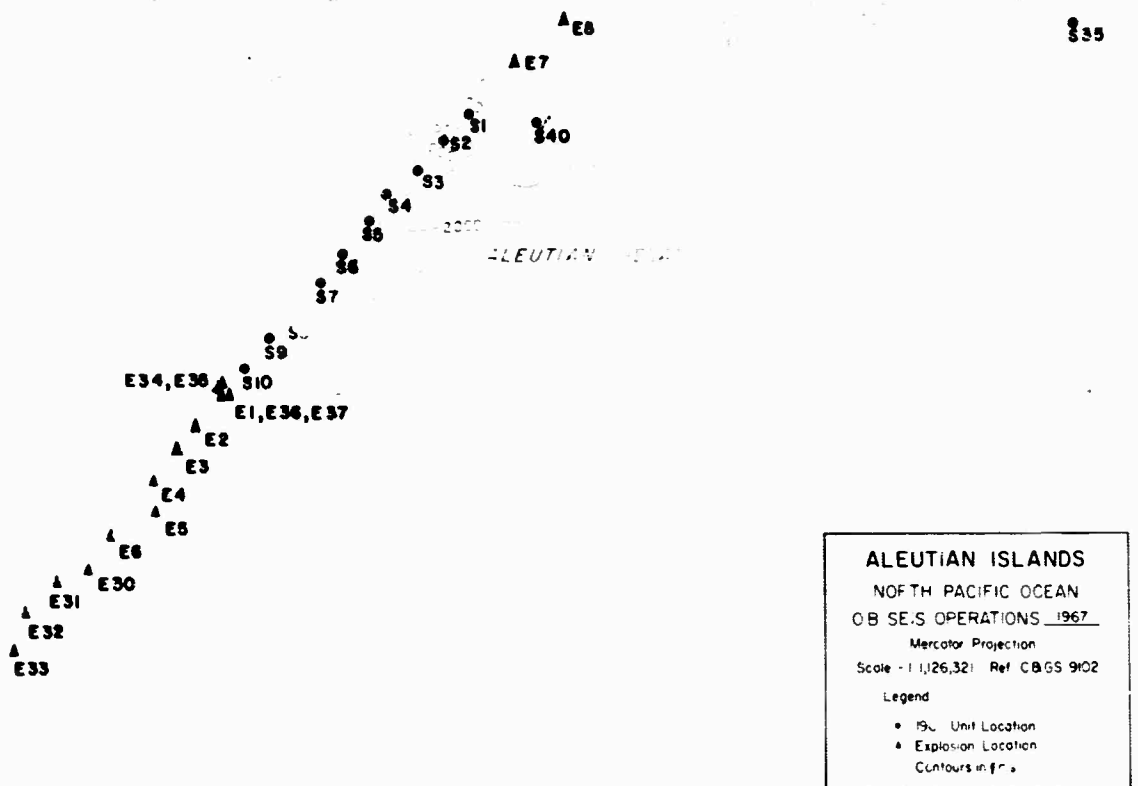


Figure III-3. Phase I Station Array



Table III-8
PHASE I STATION DROP INFORMATION

Station	Unit	Drop Date (GCT)	Location		Est. Accuracy (mi)	Water Depth (fm)
			Latitude	Longitude		
S1	21	31 Aug.	51°25'12"N	178°45'00"E	± 1/2	187
S2	19	1 Sept.	51°16'24"N	178°32'00"E	± 1/2	785
S3	13	1 Sept.	51°09'18"N	178°20'24"E	± 1/2	1920
S4	1	1 Sept.	51°01'00"N	178°06'48"E	± 3/4	1748
S5	20	1 Sept.	50°53'15"N	177°59'42"E	± 3/4	2580
S6	18	2 Sept.	50°45'00"N	177°46'00"E	± 3/4	2980
S7	15	2 Sept.	50°36'20"N	177°37'00"E	± 3/4	3840
S8	22	2 Sept.	50°26'12"N	177°22'42"E	± 3/4	3150
S9	24	2 Sept.	50°20'42"N	177°13'12"E	± 3/4	2850
S10	25	3 Sept.	50°11'48"N	177°02'12"E	± 3/4	2690

Primary recovery operations for Phase I stations were conducted between 9 and 11 September. Eight units were recovered by sonar recall, one unit was released prematurely by the Bulova back-up clock (unit 1 at S4), and one unit (unit 13 at S3) was not recovered (Table III-9).

Unit 1 (S4) prematurely surfaced due to a malfunction of the Bulova clock while recovery operations were in progress near S5. The presence of two transmitting signals delayed the recovery of the units, although both units were recovered eventually.

Transmitters and beacon lights on all units functioned properly. Unit 13 (S3) failed to respond to sonar recall during an extensive search on 11 September. The drop area was revisited on 16 September, and an unsuccessful search was conducted attempting clock recall.



Table III-9

PHASE I STATION RECOVERY INFORMATION

Sta.	Unit	Recall Method	Component Oper.		Remarks
			Trans-mitter	Beacon Light	
S1	21	Sonar	Yes	Yes	—
S2	19	Sonar	Yes	Yes	Unit recovered at night
S3	13	—	—	—	Unit not recovered. Sonar recall attempted 11 September; search of area on 16 September for possible clock recall also negative
S4	1	Bulova	Yes	Yes	Bulova back-up clock skipped days and prematurely released unit
S5	20	Sonar	Yes	Yes	—
S6	18	Sonar	Yes	Yes	Unit recovered at night
S7	15	Sonar	Yes	Yes	Unit recovered at night; released by sonar recall from distance of 14 mi
S8	22	Sonar	Yes	Yes	Unit recovered at night; recorder take-up reel not functioning properly, but recorder pulled tape which collected in bottom pan
S9	24	Sonar	Yes	Yes	Unit recovered at night
S10	25	Sonar	Yes	Yes	Unit recovered at night; transmitter intermittent for a few minutes after unit surfaced

2. Explosion Program

The Phase I explosion program consisted of sixteen 5-ton chemical explosions — 14 explosions between 220 km and 360 km S42°W of Amchitka Island (E1 through E6 and E30 through E37) and two explosions between 20 km and 40 km N42°E of Amchitka Island (E7 and E8). The explosion locations are presented in Figure III-3; Table III-10 contains pertinent information on calibration explosion. All shot depths were computed from hydro-acoustic data. A detailed report on shot-depth determination is presented in the preliminary analysis report under the present contract.



Table III-10
PHASE I CALIBRATION EXPLOSION INFORMATION

Event	Event Depth (ft)	Date (1967)	Detonation Time (GCT)	Location		Est. Accuracy (mi)	Water Depth (fm)
				Latitude	Longitude		
E1	619	8 Sept.	20:45:02.7	50°04'30"N	176°52'00"E	± 3/4	2527
E2	602	3 Sept.	04:37:02.3	49°55'06"N	176°39'48"E	± 3/4	2580
E3	613	6 Sept.	05:25:01.5	49°47'30"N	176°31'06"E	± 3/4	2810
E4	617	6 Sept.	19:51:12.9	49°39'50"N	176°21'06"E	± 3/4	2735
E5	604	6 Sept.	23:10:02.4	49°30'48"N	176°12'24"E	± 3/4	2715
E6	621	7 Sept.	02:36:01.2	49°23'24"N	176°02'00"E	± 3/4	2400
E7	616	5 Sept.	01:35:02.8	51°38'15"N	179°05'12"E	± 1/2	345
E8	597	3 Sept.	22:30:02.1	51°49'30"N	179°20'36"E	± 1/2	305
E30	602	7 Sept.	06:19:02.7	49°12'42"N	175°51'00"E	± 3/4	2820
E31	620	8 Sept.	06:05:02.0	49°10'06"N	175°38'36"E	± 3/4	2950
E32	616	8 Sept.	02:35:01.9	48°58'00"N	175°24'15"E	± 3/4	2190
E33	604	7 Sept.	20:57:01.3	48°49'30"N	175°18'30"E	± 3/4	2675
E34	1037	8 Sept.	22:30:02.8	50°04'42"N	176°52'00"E	± 3/4	2530
E35	324	9 Sept.	01:00:01.4	50°04'48"N	176°51'18"E	± 3/4	2560
E36	159	9 Sept.	04:45:01.5	50°03'24"N	176°54'40"E	± 3/4	2550
E37	71	9 Sept.	06:45:00.6	50°03'42"N	176°52'48"E	± 3/4	2575

A vertical array of calibration explosions was detonated at positions E1 and E34 through E37. A misfire occurred during the first attempt to detonate E36 due to a break in the firing line. The charge was cut from the box buoy in the manner described in subsection B (E10 misfire) and allowed to sink and deteriorate. The released charge posed no hazard to navigation. All other Phase I explosions were detonated without misfire.



D. NAVIGATION

Navigation during the Aleutian Islands Experiment was expected to improve over that of previous experiments because of the area of operation and the use of better equipment. When possible, five methods of navigation — Omega, Loran A, celestial, radar, and deadreckoning — were used.

1. Omega

The Omega navigation system was the principal means of navigation during the Aleutian Islands Experiment. Nineteen navigational charts covering the area of operations (Table III-11) were obtained, containing range-range-range lines for the following stations:

- ALDRA (13.6 kHz) - Omega station located in Norway
- HAIKU (13.6 kHz) - Omega station located in Hawaii
- TRINIDAD (13.6 kHz) - Omega station located in Trinidad
- GBR (16.0 kHz) - VLF station located in England
- NPG (18.6 kHz) - VLF station located in the state of Washington

In addition to the range-range-range lines, 13.6 kHz ALDRA-HAIKU hyperbolic lines also were included on the navigation charts.

Reception from three stations (ALDRA, HAIKU, and NPG) was found to be satisfactory during field operations. Diurnal corrections were obtained during three port calls: 2 to 4 July (Figure III-4), 29 to 31 July (Figure III-5) and 28 to 30 August (Figure III-6). The diurnal-correction changes correspond to expected seasonal changes as follows:



Table III-11

OMEGA NAVIGATION CHARTS USED DURING ALEUTIAN
ISLANDS EXPERIMENT

Map No.	Latitude Range		Longitude Range	
	Southern Limit	Northern Limit	Western Limit	Eastern Limit
1	56°30'00"N	58°00'00"N	172°00'00"W	167°00'00"W
2	55°30'00"N	57°00'00"N	176°00'00"W	171°30'00"W
3	54°00'00"N	55°30'00"N	178°30'00"W	174°00'00"W
4	52°30'00"N	54°00'00"N	179°00'00"E	177°00'00"W
5	52°30'00"N	54°00'00"N	177°00'00"W	173°00'00"W
6	51°00'00"N	52°30'00"N	177°00'00"E	179°00'00"W
7	51°00'00"N	52°30'00"N	179°00'00"W	175°00'00"W
8	51°00'00"N	52°30'00"N	175°00'00"W	171°00'00"W
9	49°30'00"N	51°00'00"N	175°30'00"E	179°30'00"E
10	49°30'00"N	51°00'00"N	179°30'00"E	176°30'00"W
11	49°30'00"N	51°00'00"N	176°30'00"W	172°30'00"W
12	48°30'00"N	50°00'00"N	173°30'00"E	177°30'00"E
13	47°00'00"N	48°30'00"N	172°30'00"E	176°00'00"E
14	45°30'00"N	47°00'00"N	170°30'00"E	174°00'00"E
15	44°00'00"N	45°30'00"N	169°00'00"E	172°30'00"E
16	42°30'00"N	44°00'00"N	167°30'00"E	171°00'00"E
17	41°00'00"N	42°30'00"N	166°00'00"E	169°30'00"E
18	39°30'00"N	41°00'00"N	164°30'00"E	168°00'00"E
19	38°00'00"N	39°30'00"N	163°30'00"E	166°30'00"E



- **ALDRA**

Diurnal corrections increase in both amplitude and timespan as the experiment progressed. The relatively small corrections observed during the period 2 to 4 July correspond to the long daylight travel path experienced between ALDRA and Adak during the early summer months. As the summer progresses, the amount of the daylight path decreases with a corresponding increase in diurnal corrections as evidenced by the two later diurnal curves. Note that a second "hump" (around 0200Z) begins to develop in the diurnal curve of 29 to 31 July. This phenomenon is more apparent around 0000Z in the diurnal curve of 28 to 30 August.

- **HAIKU**

An increase in corrections in both amplitude and timespan can be seen from the HAIKU diurnal-correction curves as the summer progresses. The sharp rise and fall of the diurnal curves is attributed to the sharp break between the daylight and night paths between HAIKU and Adak due to the location of both near the same longitude.

- **NPG**

Diurnal corrections also increase in both amplitude and timespan between diurnal curves of 2 to 4 July and 28 to 30 August. Unfortunately, NPG was off the air during the period 29 to 31 July, so no diurnal data were available.

An apparent increase in the daily drift between transmitting stations and the rubidium standard was indicated from the three diurnal-correction calculations (Table III-12). These drifts were considered to be rubidium-standard drifts and were used in all navigation computations during their respective periods.

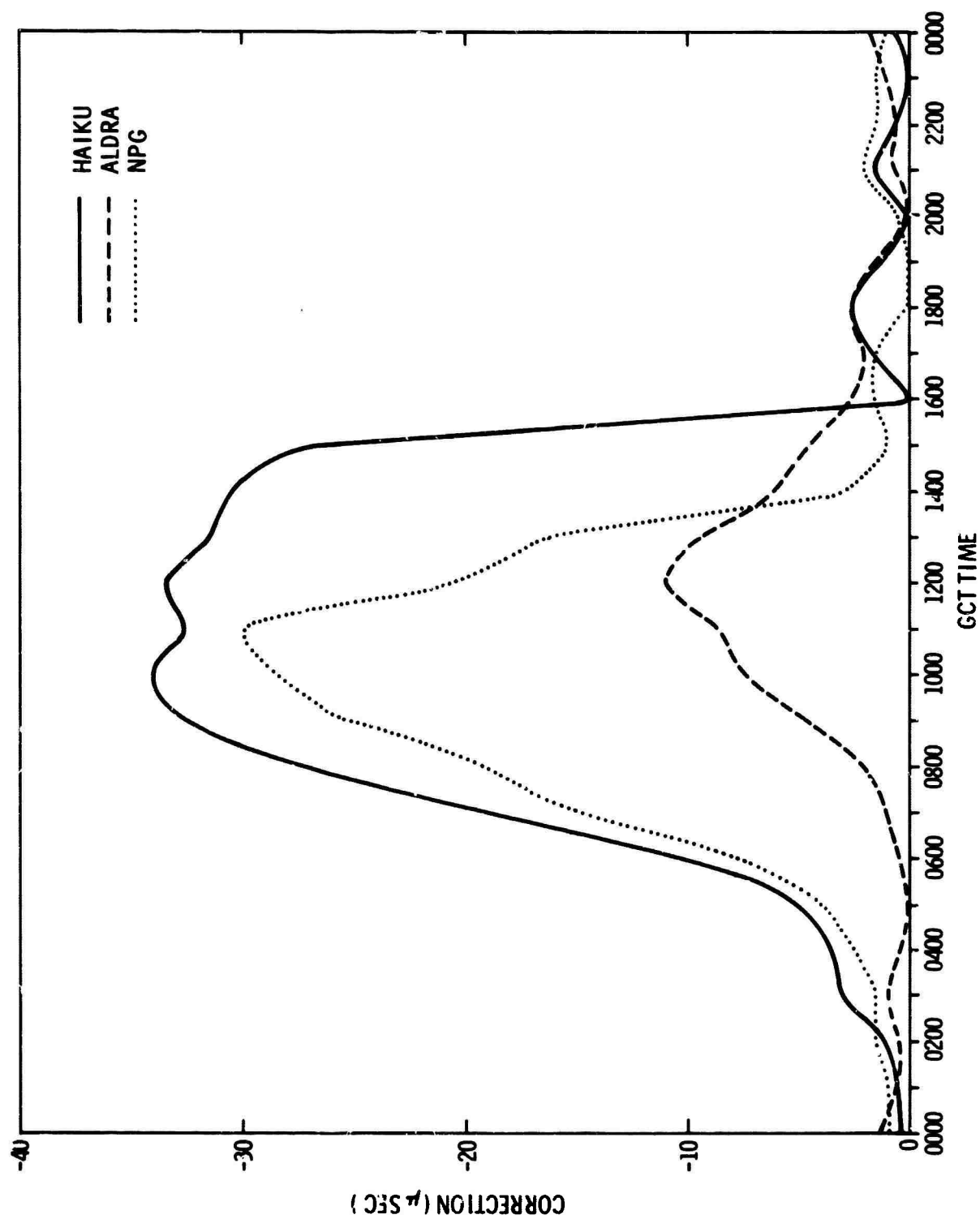


Figure III-4. Omega Diurnal Corrections, Adak, Alaska, 2 to 4 July 1967

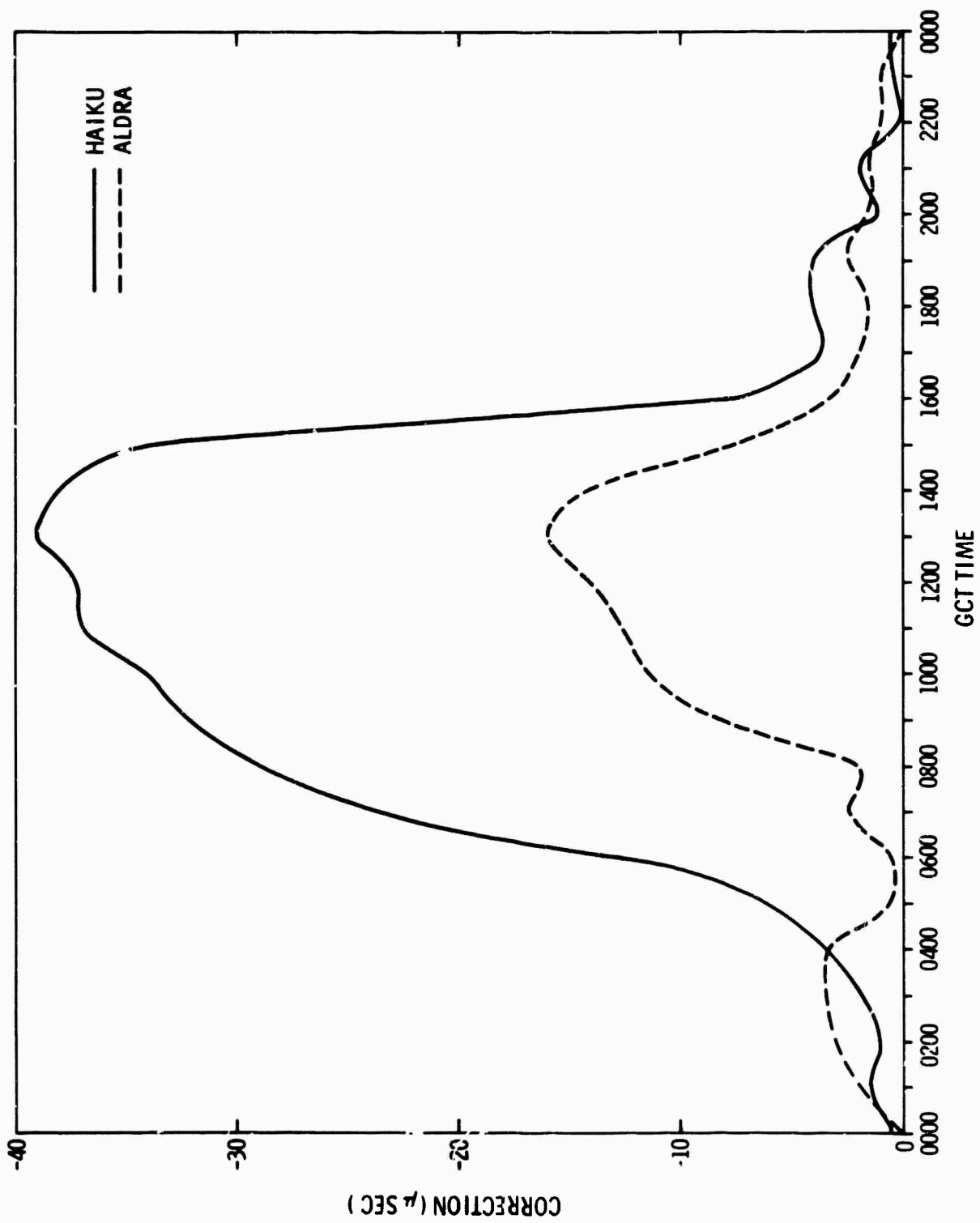


Figure III-5. Omega Diurnal Corrections, Adak, Alaska, 29 to 31 July 1967

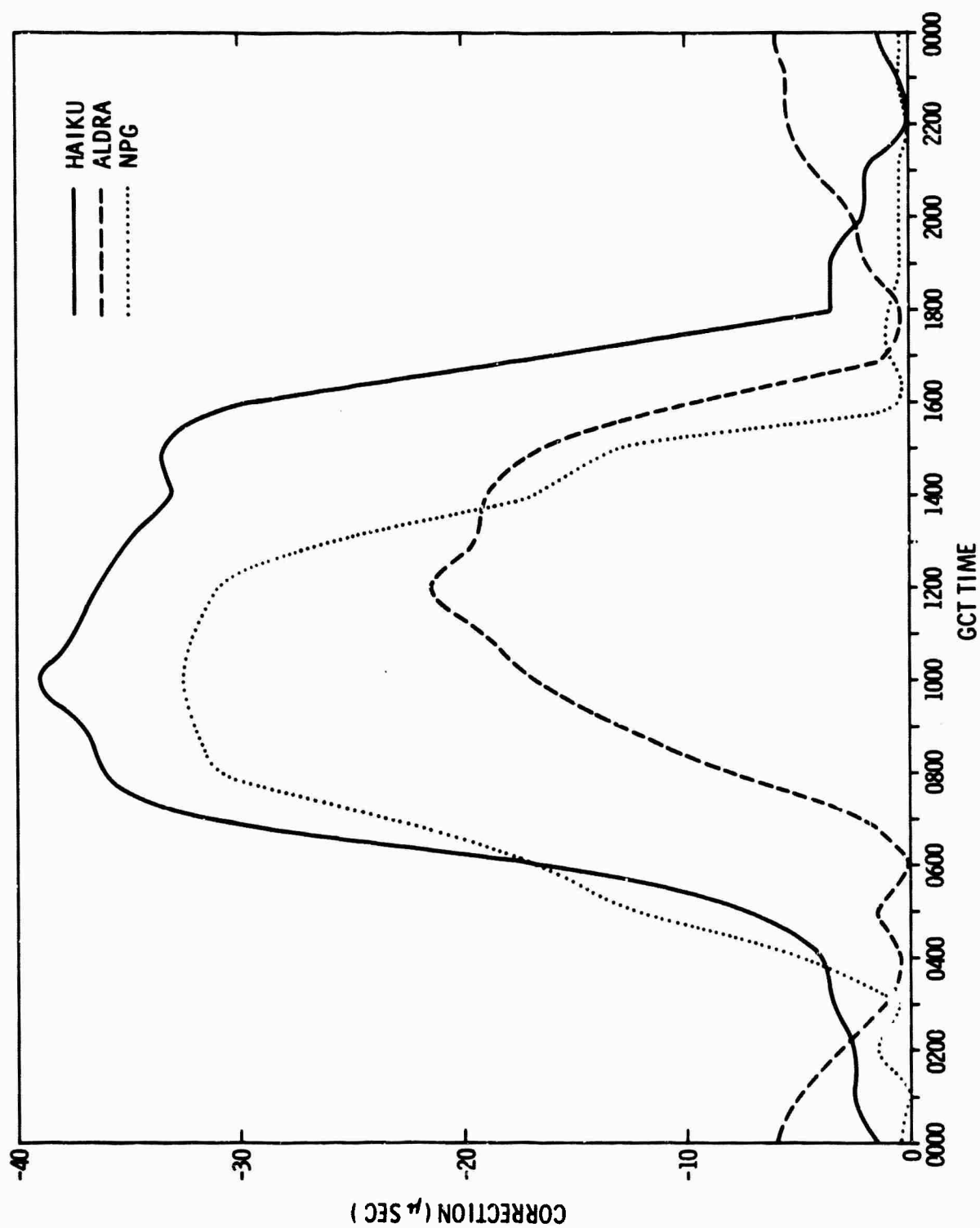


Figure III-6. Omega Diurnal Corrections, Adak, Alaska, 28 to 30 August 1967



Table III-12

RELATIVE DAILY DRIFT COMPUTED FROM OMEGA DIURNAL DATA

Period (GCT)	Rubidium Standard to Omega Stations	Rubidium Standard to NPG	NPG to Omega Stations
2-4 July	+ 8 μ sec	+ 6 μ sec	- 2 μ sec
29-31 July	+ 12 μ sec	+ 10 μ sec*	- 2 μ sec*
28-30 August	+ 14 μ sec	+ 12 μ sec	- 2 μ sec

* Estimated value; no data available

Constant monitoring of the Omega navigation equipment and the frequent use of Omega data allowed the evaluation of each station's performance and its usefulness as a navigation aid.

- ALDRA

During the early stages of operation (Adak shakedown cruise and Phase III), ALDRA was off the air on several occasions for periods of approximately 12 hr. Operations were not affected, since radar fixes were available at the time the station resumed operation and any phase shifts could be determined. ALDRA was consistent during Phases I and II of the experiment and was considered to be the overall best station. Navigation in the Aleutian area is dependent on the proper operation of ALDRA, since signals generated by ALDRA are one of the few sources for determining latitude.

- HAIKU

Very little station downtime was experienced during operations; however, unexplained "jumps" (gain or loss of several microseconds) were frequently experienced. In general, these jumps were readily identifiable from the paper chart



produced by the system if the jumps were significant ($\pm 10 \mu\text{sec}$ or greater); smaller jumps could remain hidden in the data if the ship were underway. Night reception of HAIKU signals became a problem: during operations along the southern leg of the Phase II line. One or two cycles ($73.6 \mu\text{sec}$) were either gained or lost each night. Although the consistency of HAIKU transmissions was not so good as that of ALDRA, HAIKU appears to be a useful station for navigation in the Aleutian Islands region.

- NPG

Consistency and reliability of NPG signals were greatly improved over that experienced during previous experiments. Between 24 July and 14 August, annual maintenance on station NPG caused Omega navigation to rely solely on ALDRA and HAIKU. Unfortunately, most of Phase II was conducted during this period, and the need for accurate navigation using the Omega system was critical because of weather conditions and the location of operations. During periods of station operation, usefulness of NPG as a navigational aid was demonstrated by the consistency of the data; station reliability was seen to be equal to that of ALDRA and HAIKU.

Several Omega hyperbolic fixes were taken using the range-range receivers. However, ALDRA-HAIKU readings were not used for navigation because of the sporadic jumps of the HAIKU phase trace.

Continuous Omega hyperbolic data were gathered during operations along the Phase II line south of Amchitka Island. Equipment, obtained from the U.S. Navy Electronics Laboratory in San Diego, California, consisted of an Omega Q hyperbolic receiver, Omega gating unit, and chart recorder. ALDRA-HAIKU readings were the only data that were received on



a consistent basis during the test. Although theoretical hyperbolic skywave corrections were supplied by NEL, proper tables for the area of operations were not available; therefore, hyperbolic data were not used for navigation.

2. Loran A

Rates 1L2 and 1L3 were used for Loran A navigation in the area of operations. Rate 1L2 was used successfully throughout the experiment in determining position longitude. Comparison of rate-1L2 lines with fixes determined by alternate methods remained consistent, and the excellent repeatability of the readings was used in determining successful search patterns. Rate-1L3 lines were unusable for accurate navigation, since the majority of the operations area was close to the rate-1L3 extended baseline.

Operations on the Phase II line south of Amchitka Island were conducted out of the range of either rate 1L2 or 1L3, so neither could be used for navigation.

3. Celestial Navigation

Foggy or overcast weather prevailed during most field operations; no more than a dozen good sun lines and star fixes were obtained during the experiment. Fortunately, clear weather allowed celestial fixes to be obtained while operations were being conducted south of Amchitka Island during Phase II, and the fixes supplemented the Omega navigation information.

4. Radar

The M/V VIRGO was equipped with a 10-kw, 48-mi Decca radar unit. Radar fixes when operations were conducted close to the islands provided good check points for evaluation of fixes determined by other methods.

5. Deadreckoning Navigation

The short distances between station drops and explosion locations allowed the use of deadreckoning navigation with considerable accuracy,



although no units were dropped or explosions detonated using deadreckoning fixes alone. On several occasions, especially during night-recovery operations, deadreckoning was the prime method of navigation. Results verified the value of this type of navigation when other methods cannot be employed accurately.

Overall navigational accuracy during the Aleutian Islands Experiment exceeds that of previous experiments. Because of the large amount of data available for the majority of fixes and the data consistency, the accuracy estimation of each fix was determined according to criteria presented in Table III-13.

Table III-13

ACCURACY ESTIMATION CRITERIA FOR STATION AND
EXPLOSION LOCATIONS DURING
ALEUTIAN ISLANDS EXPERIMENT

Est. Accuracy (mi)	Available Fix Data
$\pm 1/2$	Three Omega lines, Loran A 1L2 line, radar fix
$\pm 3/4$	Three Omega lines, Loran A 1L2 line
± 1	Two Omega lines, Loran A 1L2 line
$\pm 1-1/2$	Two Omega lines, contributing celestial fix within 3 hr of station drop or explosion detonation

E. COMMUNICATIONS

1. Radio and Telegraph

Status reports were transmitted at regular intervals from both the M/V VIRGO and Adak during field operations. The following equipment was available to establish the necessary communications:



- An R. F. Communications SB6FA transceiver for single-sideband and radiotelegraph between 2 and 16 mHz on pretuned switchable channels
- Three Collins KWM-2A transceivers for single-sideband and radiotelegraph on one pretuned channel between 3 and 30 mHz
- Three Collins 30L-1 linear amplifiers for 500-w output from KWM-2A excitors
- An R. F. Communications RF302 antenna coupler for matching units to 35-ft vertical whips
- A Johnson matchbox for matching transceivers to 35-ft vertical whips for 3 to 28 mHz
- A Northern N620 auxiliary receiver

Field operations required radio, telephone, or telegraph communications between the M/V VIRGO and the following:

- Port Captain on Adak

The primary communications link during the Aleutian Islands Experiment was a twice-daily contact to exchange operations information between the ship and project liaison officer. Contact was made on single-sideband radiotelephone through Radio Adak (NAVCOMSTA) on either 4489 or 4555 kHz. Early in the field program, contacts were established through the Coast Guard station via radiotelegraph.

- Adak Port Control

Required radio watches were accomplished and port clearances were obtained via communications between the ship and Adak Search and Rescue (2182 kHz) or Adak Port Control (2716 kHz) using the ship's bridge radiotelephone equipment.



- CHASE VI Operations

CHASE VI operational status reports were monitored on the ship through NPL12T (USS TATNUCK), NPL12A (Whitby Island) or NPL12W (CHASE VI Operations — Adak). No regular schedule was maintained.

- Japanese Fishing Fleet

Radiotelegraph communications were established with the Japanese fishing fleet JBKS (NISSHIN MARU No. 2) or JDAR (KYOKUYO MARU No. 2) for the purpose of relaying explosion information. Daily contacts were made during explosion phases of the experiment.

- Texas Instruments Incorporated

A daily radiotelegraph schedule was maintained between the ship and KLB in Seattle, Washington, to transmit status reports to Texas Instruments Incorporated in Dallas, Texas.

- Washington, D. C.

Radio watches were maintained by MARS (Military Affiliated Radio System); and AKLAB (Eilson Air Force Base in Fairbanks, Alaska) provided single-sideband phone-patch facilities to Washington, D. C., on an irregular basis. The ship was issued MARS call letters AKIUT for this purpose.

- Air Weather Service Aircraft

Several contacts were made via single-sideband radiotelephone with the Air Weather Service Buzzard Charlie aircraft on 4489 kHz to relay information concerning the monitoring of the Ocean-Bottom Seismograph radio-transmitter frequency.

In general, communications were conducted smoothly, and a minimum of time was lost during field operations due to required scheduled communications.



2. Shipboard Intercom System

Operational efficiency was greatly improved by the installation of Fanon Fl-7 master intercoms on the bridge, in the navigation room, engineering house, shooting shack, and RDF room. This network provided instant communication between the various stations and permitted personnel to monitor operational status of each phase of the field operations, greatly improving the efficiency of operations.

F. WEATHER

The Aleutian Islands Experiment field operations were completed within the scheduled time-frame in spite of weather conditions encountered during several periods. Adverse weather conditions affecting operations may be divided into storms and local disturbances. Storms are defined as conditions which affect the movement of the ship between various locations during field operations. Local disturbances are defined as conditions which affect the completion of various phases of the field operations while the ship is on location.

In general, the weather in the area of operations could have been termed ideal with respect to storms. Although the frequency of storms in the area increased earlier than anticipated (late August instead of the middle of September), a minimum of time (3 to 4 days) was lost during field operations as a result of storms. Because operations were completed successfully during local disturbances, delays caused by storms were avoided. Local adverse conditions, consisting of overcast skies, fog, rain, high winds, etc., prevailed most of the time during operations.

In spite of adverse local conditions, control of operations was maintained by successful use of navigation and communication, the ship's intercom system, array configuration, Ocean-Bottom Seismographs, and auxiliary equipment.



The necessity to obtain frequent sun lines and star fixes (often prevented by overcast skies or fog) was eliminated by operation of the navigational equipment on the M/V VIRGO. Successful operation of the navigational equipment also eliminated the necessity for radar fixes which were not possible during most of the period. Daily communications with the port captain in Adak and the relaying of weather information provided by Adak allowed operations personnel to anticipate storm passages and modify plans to avoid the storms. Effective use of the intercom system reduced delays and allowed plan modifications when necessary. The traveltime required between components of the arrays, especially during Phases I and III, allowed modification of plans to avoid storms. Successful operation of the Ocean-Bottom Seismographs and auxiliary equipment, especially during recovery operations, aided the completion of operational objectives on schedule. When required, units were retrieved easily in dense fog, rainstorms, and at night.

In spite of the successful on-time completion of the Aleutian Islands Experiment under the prevailing weather conditions, it is recommended that future experiments in the Aleutian Islands area be limited to the period of 1 June to 15 September.



SECTION IV EQUIPMENT EVALUATION

A. OCEAN-BOTTOM SEISMOGRAPHS

The Ocean-Bottom Seismograph units were reliable as self-contained, free-fall, remote-recall, deep-ocean instrument packages. Thirty-two instrument drops were attempted during the Aleutian Islands Experiment with 31 successes, (unit 16 was dropped at S26 but resurfaced due to a faulty ceramic capacitor in the Bulova back-up clock which caused a short and activated the release mechanism). Sonar recall was attempted on 30 units and was successful on 26 for an 86-percent sonar-recall recovery rate. The Bulova back-up clock in unit 1 (S4) caused premature resurfacing. Four units were not recovered during the field operations, although sonar recall was attempted and extensive searches of the areas during clock-release times were conducted. The overall recovery rate for the 31 successful drops was 87 percent.

A summary of recording periods for the 26 recovered units is presented in Figure IV-1. A total of 314 complete or partial days of usable data was recorded during the Aleutian Islands Experiment. An overall report on the quality of data recorded during field operations is submitted in the preliminary analysis report under the present contract.

Overall component operation during field operations is discussed in the following paragraphs.

Resurfacing of 23 of the 28 successful recoveries was determined by radio-transmitter operation. Of these, only one transmitter (unit 25 at S10) operated intermittently, and the radio transmitter began to operate properly shortly after the beacon light was sighted. Four of the remaining units were sighted and were alongside the ship before the radio transmitters

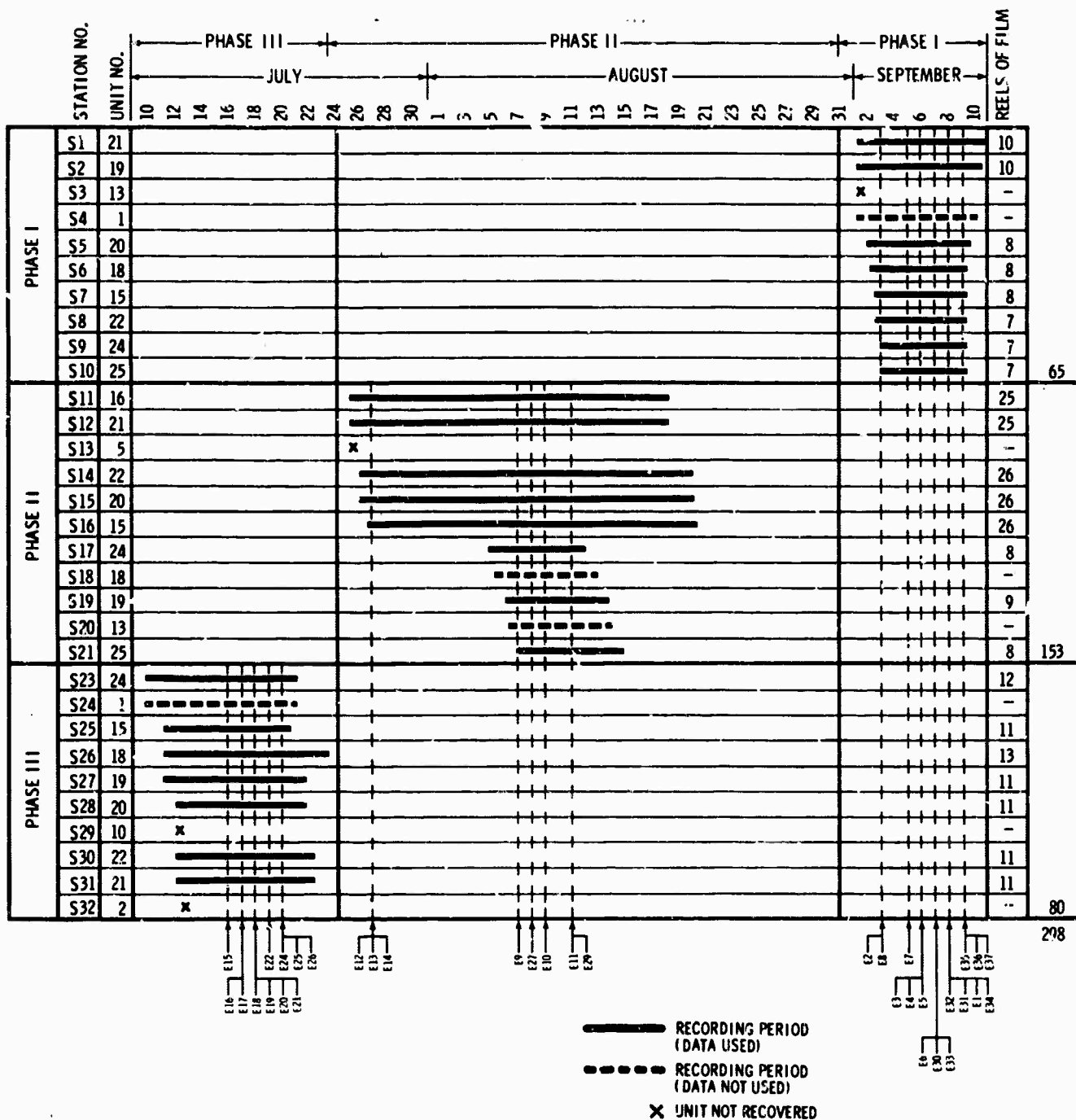


Figure IV-1. Recording Periods, Aleutian Islands Experiment



began to function properly. These units, in general, were sighted soon after resurfacing. One radio transmitter (unit 18 at S18) did not function for at least several hours after the unit was recalled. The transmitter was operating when the area was revisited 5 days later.

Failure of the beacon light was experienced on only one instrument (unit 15 at S16) during field operations. Source of the failure was traced to a pinched battery cable. Beacon light batteries were not placed in unit 21 at S12 because of the shallow drop depth (36 fm).

Playback of the data tapes in the field indicated that only one of the digital clocks failed to function properly. The clock in unit 21 at S31 did not count days correctly. The clock was returned to Dallas for repair. Two back-up clocks did not function correctly during field operations. Unit 16 resurfaced shortly after having been dropped at S26. The unit release mechanism was activated by a short in a ceramic capacitor in the back-up clock network which possibly could have been caused by impact of the unit on the ocean floor. The release mechanism on unit 1 at S4 was prematurely activated by a faulty back-up clock, resulting in the release of the unit 4 days before the scheduled back-up clock recall date.

Inspection of the units after retrieval indicated that three tape-recorder malfunctions occurred during field operations. Take-up reels did not operate properly on two instruments (unit 22 at S8 and unit 24 at S17), although both recorders pulled tape which collected in the bottom pan. Some data were lost on both tapes because of the proximity of the tape to the seismometer magnets. Playback of the data recorded by unit 24 at S17 indicated that the tape recorder was "jerky" during the recording period. The unit recorded no usable data. The problem was caused by a worn bearing in the recorder.

No saltwater leaks were experienced in any of the units that were recovered during the Aleutian Islands Experiment.



All data channels recorded by unit 13 at S20 were dead, and no usable data were recorded during the drop. The source of the problem was not determined. No malfunctions were noted on test tapes recorded by unit 13 before the drop at S20 and after recovery.

B. M/V VIRGO

The M/V VIRGO was found to be a satisfactory vessel for conducting Ocean-Bottom Seismograph experiments. The large amount of deck space and the location of the stack in the center of the rear deck allowed smooth operation of all phases. Enough space on the rear deck was available for the storage of twenty 5-ton charges.

No problems were encountered with either engine; and the vessel was able to operate on JP-5, the only fuel available in Adak.

The configuration of the living accommodations allowed personnel freedom of movement which aided morale.

C. NAVIGATION EQUIPMENT

No major problems were encountered with the Omega navigation system during field operations. However, several minor problems which did not seriously affect the equipment operation were experienced. Actions to correct these minor problems are as follows:

- The zero adjustment on the chart recorder became defective, and attempts to correct the condition failed. Although only a small amount of data was lost because of the malfunction, the recorder must be repaired in preparation for future experiments. In addition, the printer contact wire showed signs of wear at several spots and should be replaced.



- Effects of prolonged exposure to a saltwater environment affected the operation of the antenna coupler late in the experiment. It is recommended that the antenna coupler be cleaned thoroughly at regular intervals during future operations.
- Operation of the transmitting equipment on the ship affected the operation of the Omega navigation system. It was necessary to turn the time-constant switches on the receivers to 150 sec while transmissions at high power were being conducted. A common system ground should eliminate the noise problems due to transmissions and electrical storms and should be added to the system before future operations.

The D-X navigator unit located in the navigation room functioned properly throughout the experiment. Several adjustments to the D-X navigator unit located on the bridge were necessary.

D. FATHOMETER

The replacement of two recording bands was the only maintenance required on the fathometer. Excessive drying of a large portion of the recording paper complicated the collection of bathymetric data. It was necessary to keep the data trace on the wet portion of the paper using the built-in programmer. It is not known if the problem was caused by heat generated from the synchronizing lamp or by defective recording paper.

E. SECONDARY TIMING SYSTEM

The secondary timing system operated satisfactorily during the first half of field operations. The thermostat in one of the frequency standards stuck causing the crystal to overheat, but it was repaired. Constant vibration of the ship caused damage to the secondary timing system during the last half of the experiment. Vibration damage to the control units and programmers prevented the units from holding synchronization with WWV. The secondary timing system should be properly shock-mounted during future operations.



F. HYDROACOUSTIC WAVE RECORDING EQUIPMENT

No major problems were encountered in the operation of the hydrophone, WWV receiver, Visicorders, or galvo amplifiers. Difficulty was experienced in recording data from the hydrophone attached to the box buoy. Assault wire was used for data transmission, and the problem involved in recording data from a distance of 1 mi became apparent early in the operations. Initially, a breakaway device was attached to the box buoy so that the assault wire could be retrieved after detonation, but premature disengagement was experienced often during the first phase of the experiment. The assault wire was rigidly attached to the box buoy during the later phases of operation. The wire was cut at the ship after detonation, and retrieval was accomplished after pick-up of the box buoy. Although this procedure increased the amount of collected data, the time necessary to complete explosion operations also was increased.

The Ampex tape recorder proved inadequate for recording hydroacoustic data. No usable data were recorded during the experiment. A tape speed of about 15 ips is preferable to the slower speed (0.3 ips) of the Ampex recorder. Vibration and shockwave arrivals adversely affected the recorder, causing the tape to jump off the recording heads. Data recording was stopped when the hydroacoustic shockwave arrival caused overload of the power circuit breakers on the ship. Quality control of the recorded data could not be accomplished during field operations, since no shipboard playback facilities were available. The inadequacy of the system could not be determined until after completion of the experiment.

G. SONAR-RECALL EQUIPMENT

No maintenance was necessary on the sonar-recall transmitter or transducers during field operations. Of the 27 units recovered, 26 were released by sonar recall. Some difficulty was experienced in releasing Phase III instruments which had been dropped in shallow water (less than 60 fm). A possible explanation for the difficulty is that surface reflections



distort long sonar codes. Several tests were run varying the transmitter-power output and the transducer depth, but no positive conclusions resulted. However, the procedure of dropping units with short codes in shallow water and units with long codes in deeper water was established for Phases I and II.

Dependability and range of the sonar-recall equipment was demonstrated in the recovery of stations S6 through S10 during Phase I. All five units were dropped in deep water (2690 fm or greater), and computed rise times ranged from 1 hr 7 min (S10) to 1 hr 36 min (S7).

Traveltime between stations ranged from 40 min to 1 hr 10 min. The following recall procedure was adopted to minimize the time required for retrieval.

- (1) Arrive in area of first unit and begin recall. Retrieve unit after surfacing.
- (2) Begin sonar recall for next unit while previously retrieved unit is being opened. Recall should be made for 30 min; the ship should make two 10-min circles and proceed toward unit being recalled for the last 10 min.
- (3) Retrieve sonar transducer and proceed toward station location at full speed.
- (4) Retrieve unit upon surfacing and repeat steps (2) through (4).

This procedure proved quite effective as evidenced by the fact that all five units were retrieved within 10 hr after sonar recall began on the first unit. The last four units surfaced either directly ahead of the ship or shortly after the ship arrived on location. Unit 15 at S7 was released by sonar recall at a distance of 14 mi.

H. HYDRAULIC CRANE

Hydraulic leaks, which began during loading of explosives at the Dupont dock in Tacoma, Washington, persisted throughout the experiment. However, replacement of lost fluid allowed the crane to function correctly during the entire operation. A minimum of saltwater damage was incurred, and no problems such as "frozen" controls resulted. The size and configuration of the crane were excellent for Ocean-Bottom Seismograph operations.



I. COMMUNICATIONS EQUIPMENT

No maintenance was required on the radiotelephone/radio-telegraph equipment and the intercom system. Radiotelephone and radio-telegraph communications are evaluated in the following paragraphs.

Communications to the port captain in Adak were generally good once contact was established. Radio Adak was not equipped with simple phone-patch facilities, so a semiduplex operation was used. One KWM-2A transceiver was used as a transmitter and one as a receiver.

Alaskan Command Region MARS network provided excellent and almost immediate phone-patch facilities to Washington, D. C.

Communications with the Japanese fishing fleet were maintained easily on a daily basis after initial contact was made through Radio Adak.

Daily radiotelegraph reports were readily transmitted to KLB (Seattle) except in early September when the normal schedule was changed to avoid fading conditions.

The full power of the Collins equipment could not be utilized because of interference with the Omega navigation system. Interference was also observed on the WWV receivers during transmissions.

J. RECOVERY RECEIVERS

The OEC handloop functioned properly throughout the entire experiment and was used to locate all of the units which were found using the unit radio transmitter. Experimentation during recovery operations led to the following conclusions concerning the use of the handloop:

- Proper operation of the handloop depends on the unit being placed correctly on the ship. Reflections of the waves by the superstructure of the ship affects operation of the handloop. The best position on the M/V VIRGO was found to be directly in front of the wheelhouse.



- A built-in error in azimuth (approximately 10° starboard off the bow) was observed during recovery operation. This necessitated a clockwise spiral search pattern in order to locate the units.

The sensitivity of the Cadre receivers was far below that of the handloop. Reception was limited to about 4 mi. All Cadre receivers should be completely overhauled before future operations.

Operation of the twin-channel phase-detector direction-finding unit was never satisfactory. Antenna whip and sway introduced phase shifts which prevented proper operation. After eliminating antenna whip and sway, the oscilloscope-type presentation proved unsatisfactory; and overloading resulted when the ship approached the vicinity of the unit.

K. MISCELLANEOUS

During the initial detonations, it was found that the take-up speed of the firing line reel was too high. A pulley train was improvised to reduce the speed, and no further problems were encountered.

The size of the box buoys was more than sufficient to support the 5-ton cages of Nitramon; (the specific gravity of Nitramon is less than Composition B which was used in previous experiments). Both buoys must be replaced because they were destroyed during the detonation of the vertical array (E1 and E34 through E37).

No maintenance was necessary on other miscellaneous equipment such as power supplies, oscilloscopes, function generators, strobotac, tape playback unit, or electrical blaster.

Appendix C lists recommendations for required maintenance on equipment.

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SECTION V

RECOMMENDATIONS

A critique of field operations upon completion of the Aleutian Islands Experiment resulted in recommendations designed for the improvement of equipment and future operations.

A. OCEAN-BOTTOM SEISMOGRAPHS

The shallow instrument-drop depths encountered during the Aleutian Islands Experiment presented a problem. The 600-ft pressure switch could not turn off the beacon lights on six instruments dropped during Phase III. In an attempt to remedy this interference, the batteries were not placed in unit 21 which was dropped in 36 fm of water at S12 (Phase II). This removed the unit back-up recovery system. It is recommended that an investigation be undertaken to determine if satisfactory low-pressure switches can be obtained.

Delayed operation of the radio transmitter on several occasions during field operations leads to the recommendation that the transmitter pressure switch be connected and run in parallel with the saltwater path circuit so that either circuit will activate the unit upon resurfacing.

Present procedures make little use of the 24-hr calibration pulse for monitoring instrument sensitivity. It is recommended that a method be found by which the system sensitivity can be monitored.

B. NAVIGATION

Use of the Omega navigation system was hampered by station-maintenance shutdowns and sporadic jumps in the transmitted phase. In an attempt to eliminate this problem, it is recommended that a fourth range-range receiver be obtained to monitor a fourth station.



Recalculation of station and shot locations after the experiment using the Omega paper chart is difficult, since accurate records of each change of course and speed are not available. A study should be conducted to determine the feasibility of recording course and engine speed on a continuous basis using the Omega paper chart.

Although navigation capability using Omega increased sharply over previous experiments, several deficiencies should be pointed out.

- Hyperbolic Omega navigation could not be used effectively in the area of operations.
- Extended times between accurate radar fixes and the absence of favorable celestial-navigation weather decreased the effectiveness of the Omega navigation system.
- There is doubtful reliability of diurnal corrections and of apparent oscillator drift outside of a 200-km perimeter of the spot where the diurnal measurements are taken.

It is recommended that a Loran C system and/or a satellite navigational system be obtained to supply additional data for more accurate fixes.

C. TIMING

Significant timing problems exist throughout all phases of operations. Dependence on the reception of WWV time signals and incorrect field-log entries due to human error could be eliminated with a fully integrated common timing system. It is recommended that the Omega navigation system rubidium standard (accuracy of 1 part in 10^{11}) be used as a basis for a common timing system. The system could provide

- Coded GCT time trace (day, hour, minute, and second) to the CBS tape recorder at reset time and after recovery
- Coded GCT time to hydroacoustic recording equipment



- Visual GCT time at necessary locations (bridge, engineering house, radio room, navigation room and shooting shack)
- Pulses (dc) at specific intervals (day, hour, 30 and 15 min) for marking fathometer records, navigation charts, and other paper records

The ability to compare different types of data on a real-time basis is desirable in all phases of analysis, and a fully-integrated common timing system will achieve this end.

D. HYDROACOUSTIC DATA RECORDING

During explosion operations, shipboard recording of data from a hydrophone located on the box buoy via wire is difficult. If future experiments require such a hydrophone on the box buoy, recording should be done by telemetry or direct recording at the buoy.

The Ampex tape recorder should be replaced by a suitable field tape recorder capable of withstanding vibrations. The recorder should also be dc-supplied so that a breakdown in ship power does not result in data loss.

E. SEARCH AND RECOVERY

Although the light beacon serves as a reliable back-up system during nighttime recovery, daylight search and retrieval is hampered if failure of the radio transmitter occurs. It is recommended that tests be conducted to determine if the addition of a radar reflector to the radio antenna is feasible.



Development of a direction-finding crossed-loop system with visual and audio null indicators is desirable. The loops should be mounted on the highest mast to avoid ship-hardware reflections.

F. BOX BUOY RECOVERY

The presence of foggy and inclement weather during explosion operations revealed the need of a beacon light on the box buoy. It is recommended that a beacon light similar to that used on the Ocean-Bottom Seismographs be used for this purpose during future operations.



APPENDIX A
OCEAN-BOTTOM SEISMOGRAPH
PREPARATION, LAUNCH AND RECOVERY DATA

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S-1LEEDate Launched 09-01-67Sphere No. 21Date Retrieved 09-20-67Clock No. 21Sonar Code f2f2-4

OCEAN-BOTTOM SEISMOGRAPH
PREPARATION, LAUNCH AND RECOVERY DATA

Two men will prepare this list. One will make checks and readings while the other records and double-checks the first. Prepare in duplicate. One copy is to accompany tape upon recovery and the other is to be included in the Field Operations Log.

I. FINAL CHECK PRIOR TO LAUNCH

☒ 1. Battery Charging Completed

	<u>Before Drop</u>	<u>After Drop</u>		<u>Before Drop</u>	<u>After Drop</u>
B-100	<u>18.2</u>	<u>16.0</u>	B-500	<u>3.78</u>	<u>3.21</u>
B-200	<u>18.5</u>	<u>15.8</u>	B-600	<u>18.1</u>	<u>18.0</u>
B-300	<u>13.0</u>	<u>10.8</u>	B-700	<u>490.0V</u>	<u>415.0</u>
B-400	<u>3.62</u>	<u>3.45</u>	B-1000	<u>18.8</u>	<u>18.5</u>

Replace CAL battery after each 30-day drop. ☒

☒ 2. Disconnect negative release wire.

☒ 3. Set and record clock release day setting.

14 d Digital

14 d Bulova Backup

☒ 4. Set and record amplifier attenuator settings.

P 24

N-S 24

V 24

E-W 24



Ocean-Bottom Seismograph
Preparation, Launch and Recovery Data
Page 2

- ✓ 5. Set and record calibration signal settings. Set pressure at 60 db. Set all others 6 db lower than attenuator settings.
- 1✓ 6. Measure and record leakage of pressure transducer pins using Triplett meter on 100k ohm scale. Leakage should not be detectable; however, a capacitive "kick" should be seen.
- α Pin to ground (megohms)
- α Pin to ground (megohms)
- 100M Pin to pin (megohms)("kick")
- ✓ 7. Measure and record leakage of antenna to ground with antenna installed.
- 5m Pin to ground (megohms)
- ✓ 8. Tape is loaded and threaded properly, dull side up, and in good contact with heads.
- ✓ 9. Turn all switches on.
- | | | |
|---------------|-------------------|----------------------|
| <u>✓</u> Amp. | <u>✓</u> Clock | <u>✓</u> Sonar |
| <u>✓</u> Xtal | <u>✓</u> Recorder | <u>✓</u> Transmitter |
- ✓ 10. Recorder is running (if not, actuate latch relay and check end-of-tape sensor).
- ✓ 11. Transmitter is operating in pulse mode with jumper cable connected to top hemisphere.
- ✓ 12. Resistor (270 ohms) across salt water leak detector terminals actuates release system. Record voltage at release wires. Press latch relay switch on control panel to restart recorder and to regain all power. (Release voltage will be on one positive wire only.)



Ocean-Bottom Seismograph
Preparation, Launch and Recovery Data
Page 3

- ✓ 13. Resistor (1500 ohm) from antenna tip to negative release wire stops transmitter. Before disconnecting 1500 ohm resistor, connect a 15,000 ohm resistor in parallel with 1500 ohm resistor. Then remove 1500 ohm resistor. Transmitter starts again.
- 14. Connect hydraulic test unit to transmitter pressure switch. Monitor voltage on transmitter battery lead. Transmit switch "on." Apply pressure and note gauge reading when voltage reading drops. Slowly release pressure and note gauge reading when voltage reading appears on meter. —
- ✓ 15. Sonar code is f1f2-4. Sonar test signal operates flip-flops in sonar amplifier (trig T.P.) and trips release turning off recorder and amplifier power. (Check for voltage at release wires. Press latch relay reset switch to regain power to system.)
- ✓ 16. Set the pressure and north attenuator switches to 60 db. Connect output of time standard to the north channel and the output of the WWV receiver to the pressure channel. Reset clock by WWV time while recording time on tape. Record time marks for a sufficient time to obtain at least two 5-minute marks. WWV ON AT 23:00 08-31-67
- Clock Reset 23:05 GCT Date 08-31-67
- WWV OFF AT 23:10 08-31-67
- (Reset pressure and north attenuator switches if changed while recording time marks and WWV. ✓)
- BULOVA STARTED AT 23:11 08-31-67
- ✓ 17. Check 12 volts regulated at T.P. on amplifier package and amplifier d.c. offset at each detector output. (Seis input cable should be disconnected so the amplifiers will not be overloaded.)
12. 12 volts regulated 5.01Z 5.0N 5.0E 5.01P Detector d.c. volts
- ✓ 18. Reconnect seis cable and check each amplifier output at test point. Check if normal Tap sphere or transducer itself for pressure transducer excitation.



Ocean-Bottom Seismograph
Preparation, Launch and Recovery Data
Page 4

- ✓ 19. With oscilloscope, check clock test points for:
- 2.3 400 cps at 2.2 v. p-p, approximately 2.5 millisecond repetition rate
- 1.4 $12\frac{1}{2}$ cps at 1.6 v p-p, approximately 80 millisecond repetition rate
- 1.7 Time code, 2.1 v. p-p, second pulses, 1 minute between double pulses
- ✓ 20. Check bias at one of heads, approximately ~~0.9~~^{1.5} volts p-p and 150 cps. (Should be good, undistorted sine wave.)
- ✓ 21. Check all wires, plugs, cables, etc. to see that all are securely fastened.
- ✓ 22. Add dessicant inside battery boxes, attach putty cup, and lower top being sure to connect beacon radio cable to control panel and to grease "O" ring and check to see that the "O" ring is seated properly in its groove.

II. SEALING OF UNIT

- ✓ 1. Draw vacuum and record
- Start drop 7" (inches HG) 8" Upon recovery
- ✓ 2. Trip release spring compressed length — (inches).
- ✓ 3. Turnbuckles torqued down 25 (ft. lbs.)
- ✓ 4. Inspect roll-out hinge opposite release mechanism.
- ✓ 5. Install beacon light on unit.
- ✓ New battery installed.
- ✓ Pressure switch checked for proper operation.



Ocean-Bottom Seismograph
Preparation, Launch and Recovery Data
Page 5

☒ Light flashing when dropped.

☒ 6. Connect negative release wire.

Remarks: REMOVED Silastic Compound Mixture of Clear
& PINK Silastic- Substituted with ALL PINK Silastic
THE Mixture of Clear & PINK will be used in Unit #19-
would like to determine if the mixture of Silastic
is A better coupling compound than the PINK
Silastic used by itself.

Unit off Quick Release AT 00:23 09-01-67

Prepared By Don Siebert and _____

Date 08-31-67



Phase I 51-UNIT 21

Ocean-Bottom Seismograph
Preparation, Launch and Recovery Data
Page 6

III. LAUNCH DATA

Clock Start

Secondary Standard Error 0.0 at 8, 31, 20, 00 GCT
Mo. Day Hour Min.

Secondary Standard No. 1.

WWV Start 8, 31, 23, 00 GCT
Mo. Day Hour Min.

Clock Reset 23, 05 GCT
Hour Min.

WWV Off 23, 10 GCT
Hour Min.

Launch Data

Time Unit Released For Drop 9, 1, 00, 23, 03 GCT
Mo. Day Hour Min. Sec.

Depth 187 Fath. Determined By fathometer

Wind 5 Kts. Sea State 5-10 ft. Swells

Barometer 29.65 Position 51

Latitude 51°25'N Longitude 178°47'E

Determined By OMEGA, RADAR, & LORAN (142)
(51°25'18"N
178°46'30"E)

System Information

Sphere No. 21

Clock No. 21



Ocean-Bottom Seismograph
Preparation, Launch and Recovery Data
Page 7

Battery Voltages: B-100 - 18.2 V (Recorder)

B-200 - 18.5 V (Amp.)

B-400 - 3.62 V (Clock)

B-300 - 13.0 V (Amp.)

Signal Attenuation: P 24 db N 24 db

Z 24 db E 24 db

Release Settings:

Digital Clock 14 days

Bulova Backup 14 days - hours

Prepared By: R. F. Howard

Date: 8-31-67

Remarks:

Light O.K.
Transmitter O.K.



Ocean-Bottom Seismograph
Preparation, Launch and Recovery Data
Page 8

IV. RECOVERY DATA

Sphere No. 21 Clock No. 21 Position 51

Time Sonar Recall Begins 9 Mo. 10 Day 19 Hour 10 Min. GCT

Time Unit Determined on Surface 9 Mo. 10 Day 19 Hour 52 Min. GCT

Determined By TRANSMITTER

Location

Latitude 51°25' N Wind 3-5 Kts.

Longitude 178°47' E Barometer 30.05

Determined By Omega E Radar Weather Clear, Calm, & Cool

Unit Data

Time Unit Onboard Ship 9 Mo. 10 Day 20 Hour 05 Min. GCT

Time Sphere Opened 10 Day 20 Hour 33 Min. GCT

Secondary Standard Error 0.0 at 9 Mo. 10 Day 20 Hour 30 Min. GCT

Secondary Standard No. 1

Latch Relay Depressed 10 Day 20 Hour 40 Min. GCT

WWV Start 10 Day 20 Hour 45 Min. GCT



Ocean-Bottom Seismograph
Preparation, Launch and Recovery Data
Page 9

WWV Off 20 , 55 GCT
Hour Min.

Amp. Off 20 , 56 GCT Clock Off 20 , 57 GCT
Hour Min. Hour Min.

Recorder off 20 58
Tape Marked: 9-10 , 67 , 21 , 21
Day of Year Year Unit No. Clock No.

Battery Voltages:

B-100 16.0 v (Rec.)

B-200 15.8 v (Amp.)

B-400 3.45 v (Clock)

B-300 10.8 v (Amp.)

B-700 415 v (Light)

Prepared By: R.F. Howard

Date: 9-10-67

Remarks:

Light & Transmitter O.K.

Good WWV signal



APPENDIX B
SAFETY REGULATIONS FOR HANDLING EX.PLOSIVES

science services division



APPENDIX B

SAFETY REGULATIONS FOR HANDLING EXPLOSIVES

The following regulations are safety procedures which are in effect during the loading, storage, preparation and launch, and detonation of explosives during Ocean-Bottom Seismograph operations. Responsibility for observance lies with the shooter and shooter's helper. Responsibility for enforcement lies with the safety engineer, operations manager, and captain.

Loading

Each type of explosive must be loaded or unloaded separately.

No smoking will be allowed during loading or unloading.

Only a minimum number of personnel will be allowed in the immediate area during loading or unloading.

All transmitting equipment will be turned off during loading or unloading.

Fire equipment including dock water hose must be laid out and ready for quick use.

Special care must be exercised in handling blasting caps and primers; only the shooter or helper will load, unload, or handle these items.

Large prepackaged charges will be loaded and moved only by an experienced crane operator.

Storage

Explosives must be stored properly in magazines, allowing proper ventilation and braced with supplied dunnage material.

Magazines are to be used only for explosives and must be kept clean of dust, packing material, etc.



Magazines must be kept locked at all times when not in use; the shooter, operations manager, and captain will be the only keyholders.

An accurate count of all expended explosives will be kept by the shooter, and copies of this count will be submitted to the operations manager and captain at the end of each day when explosive detonations occur.

A complete inventory of explosives aboard ship will be made at the discretion of the operations manager.

Preparation and Launch

Work vests will be worn by all personnel assisting in preparation and launch operations.

The prepackaged charge will be secured to the fantail of the ship before priming operations begin. Charges will be moved only by an experienced crane operator.

Sufficient working space will be provided on the back deck before priming operations begin.

Only a minimum number of personnel will be allowed in the immediate area during preparation and launch operations.

The crane hook will be attached to the A-frame before priming operations begin.

The shooter will request a sweep by the ship's radar for any ships within the area and will request that all transmitters be secured if area is clear.

No explosive detonations will be attempted during electrical storms.



A check will be made by the safety engineer to insure that all transmitting equipment has been secured before priming operations commence.

The shooter's helper or safety engineer will assist the shooter in removing from the magazine primers, boosters, and necessary items required for the present charge.

Only static-resistant caps will be used during operations.

All blasting caps must be placed in the lead-lined safety box as soon as possible after their removal from the magazine.

The shooter or shooter's helper are the only personnel allowed to place primers and boosters in the main charge.

All safety switches must be in good working order and must be checked before the caps are attached to the firing line.

After continuity checks are completed, the blasting caps will be connected to the firing line. This connection will be made as soon as possible after the shorting shunt is removed from the cap leads.

Placing of the blasting caps in the main charge constitutes a "committed-to-go" condition, and the charge must be launched as soon as arming is complete.

Detonation

No safety switches or transmitting equipment will be operated until the ship is a safe distance from the charge.

Every effort will be made to keep the charge directly behind the ship at detonation.



In the event of a misfire, the charge will be cut off the buoy. The charge will never be brought back onboard the vessel.

Firing line and shooting equipment will be thoroughly tested at the discretion of the shooter or operations manager after additional firing line has been added, after equipment has been repaired or replaced, and after a misfire has occurred.



APPENDIX C
RECOMMENDATIONS FOR REQUIRED
MAINTENANCE ON EQUIPMENT

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APPENDIX C

RECOMMENDATIONS FOR REQUIRED MAINTENANCE ON EQUIPMENT

All equipment should be restored to first-class condition after the completion of each major field experiment. General cleaning, replacement of damaged parts, and continual upgrading of equipment cannot be overstressed, as the success of any field operation depends on the ability of each piece of equipment to function properly.

Recommendations for required maintenance on equipment following the Aleutian Islands Experiment follow.

OCEAN-BOTTOM SEISMOGRAPHS

Unit 1	Replace amplifier system with RA-6 package and add necessary batteries and wiring for uniform systems; replace springs; complete general repair of tape recorder
Unit 16	Replace corroded center ring and repair pressure transducer
Unit 20	Reanodize and paint upper hemisphere
Unit 22	Reanodize and paint center ring
Unit 24	Reanodize and paint center ring
Unit 25	Replace amplifier system with RA-6 package and add necessary batteries and wiring for uniform system; return Bulova Acutron clock to factory for repair
General (includes all units)	Clean completely Thoroughly check each component Replace all O-rings Replace all bent turnbuckles and rings



Replace all beacon-light batteries
plus spares

Replace antenna springs

Plastic-coat cables on bales and other
hardware

Replace any batteries dated 1966 or
earlier

Obtain spare light, transducer, and
amplifier to insure total capability
of instruments

Build spare sonar test box

AUXILIARY EQUIPMENT

Sonar Transmitter	For unit 1: replace underrated transistors and rectifiers; for unit 2: clean
Sonar Transducer	Repaint and check for broken or damaged crystals
Playback Tape Recorder	Rebuild selector-box switch assembly
Paper Chart Recorder	Repair four galvanometers
Galvo Amplifier (2 units)	Clean
Fathometer (2 units)	Return to factory for servicing
D-X Navigator (2 units)	Return to factory for maintenance and calibration
Omega Navigation System	Have factory representative clean and repair in Dallas; add common ground to eliminate noise; obtain spare parts
WWV Receiver (2 units)	Return to factory for maintenance and alignment
OEC Loop	Clean; replace batteries
Electrical Blasters	Clean
Oscilloscope (4 units)	Clean and complete necessary maintenance and calibration
Function Generators	Clean and perform calibration check



High-Frequency Generator	Clean and calibrate
Strobotac	Clean and calibrate
RF Dummy Load and Wattmeter	Clean
Volt Ohmmeter (5 units)	Return for repair and maintenance, calibration and cleaning
Hammarlund Receiver	Clean, realign, and install 3-wire power plug to prevent "hot" chassis problem
KWM-2A System	Clean and check
Ampex Tape Recorder	Replace amplifier channels; obtain spare parts
Geotech Timing System (2 units)	For unit 1: replace frequency standard, obtain solid-state programmer, clean and check. For unit 2: replace frequency standard, clean and check
Box Buoy (2)	Replace
Hand Tools (2 sets)	Clean and replace missing or unusable tools

DOCUMENT CONTROL DATA - R&D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author)

Texas Instruments Incorporated
Science Services Division
P. O. Box 5621
Dallas, Texas 75222

2a. REPORT SECURITY CLASSIFICATION

Unclassified

2b. GROUP

3. REPORT TITLE

OPERATIONS REPORT, ALEUTIAN ISLANDS EXPERIMENTS, OCEAN-BOTTOM
SEISMOGRAPHIC EXPERIMENTS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Special Report

5. AUTHOR(S) (Last name, first name, initial)

McDermott, Joseph G.
BeAbout, Edgar G.
Guidroz, Ralph R.

6. REPORT DATE

31 January 1968

7a. TOTAL NO. OF PAGES

95

7b. NO. OF REFS

1

8a. CONTRACT OR GRANT NO.

F33657-67-C-1341

8b. ORIGINATOR'S REPORT NUMBER(S)

b. PROJECT NO.

VELA T/7704

9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. AVAILABILITY/LIMITATION NOTICES

Distribution of this document is unlimited.

11. SUPPLEMENTARY NOTES

ARPA Order No. 624
ARPA Program Code No. 7F10

12. SPONSORING MILITARY ACTIVITY

Advanced Research Projects Agency
Department of Defense
The Pentagon, Washington, D. C. 20301

13. ABSTRACT

An Ocean-Bottom Seismograph Aleutian Experiment was conducted during the summer of 1967. The objective of the experiment was to obtain data for the determination of thickness and seismic velocities of the crust and upper-mantle structure by deployment of three linear arrays of instruments in the vicinity of Amchitka Island and by detonation of a series of chemical explosions. Several tasks involved in the completion of the experiment were equipment preparation, ship-rigging, shakedown cruises, and field operations. In general, the OBS units and auxiliary equipment performed reliably so that the experiment was completed with a minimum number of problems within the specified schedule.

KEY WORDS

Ocean-Bottom Seismograph
Aleutian Islands Experiment
Equipment Preparation
Ship-Rigging
Shakedown Cruise
Field Operations
Explosion Program

LINK A

LINK B

LINK C

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